ROADS AND STREETS

PUBLISHED MONTHLY BY ENGINEERING AND CONTRACTING PUBLISHING COMPANY
221 EAST 20TH STREET, CHICAGO

HALBERT P. GILLETTE, President and Editor
R. W. HUME, Vice-President
FREDERIC KAMMANN II, Advertising Manager
New York Office, 441 Lexington Avenue: ERWIN T. EYLER, Eastern Manager

The specialized publishing plan of Engineering and Contracting provides four rotating monthly magazines, each of which is $2.00 a year.

Roads and Streets—1st Wednesday
Water Works—2nd Wednesday
General Contracting—3rd Wednesday
Buildings—4th Wednesday

All four may be subscribed for at the special rate of $5.00 a year, and thus taken they provide a weekly service completely covering the construction field.

Foreign Postage 65c extra for each magazine

Copyright, 1926, by Engineering and Contracting Publishing Company

Vol. LXV CHICAGO, JUNE 2, 1926 No. 6

Encourage Brains to Immigrate to America

We know many principles but we put none of them to full use. We know, for example, that our supremacy over the beasts is attributable solely to superior brain power. But we do not, therefore, cultivate our minds to any great extent. We do not even follow the advice of specialists. We vote on economic matters about which we are profoundly ignorant, and have the hardihood to deride men who refuse to vote when they lack knowledge. We write laws that restrict immigration without regard to the mental quality of the immigrant. We unveil a monument to the inventor of the screw-propelled ship and the "Monitor," but we would not admit John Ericsson's spirit to our shores today were Sweden's immigration quota filled the day before his arrival. We honor the man who made transcontinental telephony possible. We make him professor of electrical engineering in a great university. Many of us buy his inspiring autobiography, "From Immigrant to Inventor." But if another Michael Pupin were planning to enter America today he would probably be thinking of how to "bootleg" his way into this land of opportunity.

Verily, our ignorant acts are the numberless sands of the sea, and our wise ones are the few gems that a small band of pearl-divers have found. The pearl-divers of America are our men of brains—our inventors, scientists, engineers, business leaders. One in a hundred, often one in ten thousand, they are, immigrants in person or the descendants of immigrants. Yet without regard to the supreme value of such men to the rest of society, we solemnly put out our sign at Ellis Island, "Not even standing room today in America for the Ericssons and the Pupins unless they fall within this year's quota." It is well that smart men should not be judged by their silly acts.

It may be the part of wisdom temporarily to restrict general immigration, but surely it is folly ever to restrict the immigration of men of superior brain power. On the contrary, we should bid them come, entreat them to come. The more the richer we shall be, even though they come penniless.

California diligently advertises her climate, and her resources, and wins her way toward leadership among the states. America might well do the same sort of advertising in Europe, calling upon the best brains of Europe to come where brains are best rewarded and most honored. Let Russia exile her brains and try her socialistic experiments to the limit. Let America welcome and adopt these exiles, and as many such as can be persuaded to join the great exodus of intellectual and business leaders. Let the two extremes of theory be then tested to the limit, the theory that labor is the prime creator of wealth and the theory that brains is the prime creator of wealth. Russia is a land of boundless natural resources and it is the home of a virile people who outnumber us three to one. But it has always been deficient in trained intellects, and now is more handicapped than ever since the overthrow of capitalism. America has long been the land of fair promise and the home of successful performance. America owes its economic greatness primarily to the large percentage of able men whom it has attracted to its shores, and secondarily to the freedom that they have had to promulgate new theories and to put their ideas to the test of experiment. Here there was no system of caste—that form

of trade unionism that is so ancient that it has become sanctioned by custom and even sanctified by religion. Here was freedom to accomplish anything that brains might dare and that energy might execute. Here also was applause and honor for the man who could make two motor cars roll where one horse and buggy rolled before. As a nation we have been unique in accepting successful industrial leaders at their own appraisal, namely as men whose ability deserves to be ranked with that of statesmen. In Europe they still look upon 'trade" as a necessary evil. Their writers still applaud only artists, philosophers and one another. Their idea of vast ability is an orator like Lloyd George, rather than a manufacturer like Henry Ford. Yet Great Britain would do well to export Lloyd and import Henry, even if she paid a few billion dollars to boot in the transaction.

In less than a century the buying power of the average American worker was increased four fold, because his productivity has increased four fold. Did muscle do it? A Chinese coolie is as strong as the average American worker. Did natural resources do it? The American Indian had them at his disposal for centuries. Did restricted immigration do it? On the contrary, without immigration there would have been no America. Did government do it? No government ever did anything greatly worth while, save to secure freedom and a measure of peace and to preserve personal and property rights.

The economic progress of America had begun to attract attention before the thirteen colonies revolted. Adam Smith speaks of the very high wage rates and low costs of living that the colonists enjoyed. Brains, freedom to use them, and a general willingness to follow where brains led—these constitute the triumvirate that have made America the envy of the world. We are advertised by our own prosperity as never a nation was advertised before. The artists and art products of the world seek our dollars. Leaders in applied and pure science are looking enviously toward America. European editors lecture their readers about our success. Foreign cartoonists emblazon Uncle Sam's clothes with dollar marks. They envy us, yet they hate us for our success. Forgetful that we were equally successful before the war, they often claim that the war made us rich. The war really set us back several years in our march toward greater prosperity.

There is but one way in which we can turn all this envy and hatred into an asset, and that is by using it to assist us in winning away from the "old countries" more of her brainiest men and women. We do not monopolize the best brains of the world as yet, but let it be our aim to approach to that ideal.

Engineering Applied to Biology

By HALBERT P. GILLETTE, *Editor*

Herbert Spencer's philosophical works show repeatedly the successful application of his engineering knowledge to problems that had not been previously regarded as needing any assistance from engineering. No engineer, therefore, should hesitate to offer a suggestion to a biologist, provided the suggestion is based on engineering principles.

The Literary Digest, quoting from a recent article in The Journal of Mammalogy, states that pulling tests discloses that a chimpanzee is several fold stronger than a man, not only weight for weight but muscle girth for muscle girth. The author says: "Probably cross-section for cross-section of muscle man stands (in strength) materially above the bulk of the animal species. The animals outranking him, it would seem, are the carnivora, the other primates (monkeys), and such animals as the mole, etc."

It would occur to an engineer that neither the strength per pound of total body nor the strength per square inch of muscle is a proper unit by which to compare muscular strengths. To begin with, a dynamometer record of a pull measures only force and not energy. A very small amount of energy can develop an enormous pull, if leverage is applied, as witness the pulling of a large tree stump by a man aided by a stump-pulling machine.

The total weight of an animal body bears no necessary relation to the energy that can be developed by any set of muscles. Thus, the gripping strength of an ape's tail would scarcely be expressed in pounds per pound of the ape's entire body. Nor would it be any more rational to measure such a gripping strength in terms of the cross-section of the tail muscles. The strength of each set of muscles should be measured in terms of the weight or volume of those muscles, due allowance being made for the leverage with which they act.

An ape has great pulling strength in its biceps not merely because they are large in cross-section but because they are long. Among athletes it is noteworthy that men of equal strength of biceps may differ greatly in the cross-section of the biceps, but that in such cases where the cross-section is small the length of the biceps is great.

If we had a correct theory of muscular power, we should be able to explain why it varies approximately as the weight of the muscle and not as its cross-section. Let us consider an hypothesis that suggests itself.

Although most substances expand when heated there are a few that contract, notably rubber. If the muscles contains a substance that contracts when heated, then the explosive combustion of some of the tissues will cause muscular contraction. Granting this, it follows that the contractile strength of a muscle will vary with its volume, just as the expansive push of a steel rail when heated varies with the volume of the rail.

All materials have different co-efficients of heat expansion (or contraction) and different moduli of elasticity; hence it is certain that the muscles of different species of animals will differ somewhat in contractility even where the volume of the muscles is the same. But it is probable that for two closely related species, the main difference in contractility will arise from differences in the volume of the muscles.

The legs of a man are larger than those of an ape, hence tests of leg strength will probably show man's superiority over an ape; while the contrary will hold as to their arms.

New Traffic Regulations in Wisconsin

The State Highway Commission of Wisconsin at its February meeting adopted the following regulations:

Warning Signs.—1. Except as hereinafter provided, the standard warning signs with black letters and border on a yellow background, adopted by the conference called by the Secretary of Agriculture of the United States, and held in Washington, D. C., Aug. 3 to 7, 1925, shall be standard for their respective purposes in the state of Wisconsin, and no other signs shall be used for such purpose, except that existing warning signs shall remain until replaced with such standard signs. The standard signs shall be installed on the U. S. Highways in connection with the U. S. marking, and on the other portions of the state trunk highway system, the county trunk highways, and other routes as soon as practicable.

2. In view of the necessity of conserving space the "Stop" signs in cities shall be 20 in. where the standard stop sign is 24 in.

3. "School" signs in cities shall be 20 in. square.

4. Warning and stop signs in cities shall be of metal with the letters and border raised or embossed.

5. The installation of all warning signs in cities shall be carried out by the city organizations.

Arteries for Through Traffic.—1. Standard octagonal "Stop" signs shall be installed at all places where the traffic is required to stop for an artery for through traffic. Such signs shall be erected at the right hand curb, not less than 6½ ft. nor more than 8 ft. above the street. On such signs the word "through" shall be spelled "thru."

2. Where arteries for through traffic intersect, the stop shall not be required of traffic along the heaviest travelled artery, or, if this is impracticable, an automatic signal device shall be installed.

Automatic Signal Devices.—1. All automatic traffic signal devices for regulating traffic at street intersections shall be installed at the four corners of the intersection, and no further installations at the center of the intersection shall be made.

2. Such traffic signal devices shall be installed adjacent to the curb and 2 ft. back of the outside sidewalk line of the intersecting streets. The height of the center of the signal above the street shall be not less than 6½ ft. nor more than 8 ft. Such devices shall be painted yellow to match the color of the warning signs. The lights in such signal devices shall be two-way; that is, visible in both directions along the street and shall be so arranged as to show a green light to indicate "Go," red light to indicate "Stop," and an orange light to indicate "Traffic Change."

3. The words "Stop," "Go," and "Traffic Change," shall be shown to supplement the colors.

Massachusetts to Spend $13,000,000 on Roads.—According to the State Department of Public Works more than $13,000,000 will be expended by Massachusetts this year on state, county and town highways. The department will expend $1,500,000 on the construction of new state highways, and $1,600,000 as its share of the construction of town and county ways. Towns and counties will contribute about $3,000,000 in this cooperative arrangement. The department will also expend about $120,000, the remainder of a special appropriation, for highways in the western counties of the state; and there is available also $1,800,000, a special appropriation, for the construction of the new Southern Artery—a big cut-off boulevard from Morton St. and Blue Hill Ave., Dorchester, to the Fore River bridge in Quincy. There are 1,521 miles of state highway to be maintained, some of which will have to be rebuilt, for which the department has an appropriation of a little less than $6,000,000.

Bids to Be Taken on Large Highway Job in Cuba

According to a special circular of the Transportation Division of the U. S. Department of Commerce advertisements for bids on the Central Highway in Cuba will soon be published and contracts will be awarded, according to definite plans now established, during the month of August, next. Specifications are practically completed though minor amendments are now being made before they are finally sent to the printer. The specifications will be issued before final surveys on the highway are completed, but sections now lacking are being rushed to completion and will be available in ample time before the date on which bids are to be received. Bids are to be made on a unit cost basis.

The Secretary of Public Works has officially published a statement on the conditions for bids, especially as regards time, penalties for delays, unit costs, manner of payment, etc. This statement will be made one of the clauses of the conditions for bids. In order to enable bidders to make more definite calculations, the Government will guarantee a minimum annual revenue, on the basis of Public Works returns, which will probably be fixed at $6,000,000.

The most important point for the Government to consider is the method of financing, assuming that competent concerns will bid on the project. The Government hopes to accomplish construction of the Central Highway in four or five years. In this case, the revenues under the Public Works Fund will not be sufficient to pay for the work annually as it is done, but would require the postponement of payment over the entire ten-year period, in which the existing taxes are to be in effect. But, Article X, of the Public Works Law of July 15, 1925, specifically prohibits the Government from contracting for work for which payment cannot be made each fiscal year with the normal Public Works revenue. President Machado stated recently that he would rather the road was not built if the Government had to issue bonds, and the Secretary of the Treasury, Dr. Hernandez Cartaya, refuses to attempt evasion of the provision in the law above quoted by the issuance of any specially designed certificates, notes or acknowledgments.

Two other methods may be considered: The issuance by the Department of Public Works of certificates for work done, or the more conservative plan of financing the improvements on a cash basis. The former method of financing would be more expensive than a bond issue. As regards the risks which would be assumed by those financing the project, the Special Public Works Fund would not constitute a real guarantee for the creditors. The guarantees of the present Public Works Law are none other than personal credit of the Cuban Government. Though ten years is fixed by the law for the completion of the work, the Government is not obliged to maintain the tax during that period, and there is no provision in the Cuban Constitution which would prevent Congress from cancelling such taxes under a succeeding administration. In such an event creditors would be obliged to collect from the Government when and how they could. Under the plan of financing the improvements on a cash basis only those works would be contracted for which could be completed and paid for by the revenues to be received during the Machado administration from the special taxes in effect. This plan would better protect Cuban credit abroad. The adoption of either of these two methods will probably be dependent upon the bids and, consequently will not be decided upon until August.

As regards the total revenues which may be expected from the Public Works Fund, Secretary of Public Works Cespedes, in a letter dated April 12, to President Machado, stated:

"The nine months that the taxes have been in force allow me to affirm without any doubt their efficient potentiality. The estimates which we took into consideration upon proposing the law have been met in practice; the administration of these taxes has not presented difficulties of any kind; they are almost as a whole, due to their nature, very plain and very simple of collection. It has been observed that the people pay these taxes with pleasure, partly due to faith in the present administration and partly because they know that the proceeds will be directly invested in constructive work.

". . . . During the present year, collections will exceed eleven million dollars; and next year, with the inclusion of the five million dollars assigned in the budget, and with a more practical administrative machinery, the proceeds will exceed seventeen million dollars. Several experts, both national and foreign, agree that it is not going too far to estimate a total of two hundred million dollars for the Special Public Works Fund in the ten years."

No Road Work on Sundays.—According to a press report no Sunday work is to be permitted in the construction of new highways in Salem County, New Jersey, even under the pretext of "emergency work" by contractors. A unique provision has been made in the first road contract for the current year, which will be in force on the Salem-Hancock's Bridge road.

Asphaltic Concrete Construction at Cortland, N. Y.

Methods and Costs—High Grade Open Hearth Slag Used as Coarse Aggregate

By DWIGHT B. COLEMAN
City Engineer, Cortland, N. Y.

The city of Cortland is just now embarking upon its second season's work in the construction of "black base" pavements and its fourth year of operation of a municipal asphalt plant.

Local Conditions.—Cortland is the county seat of Cortland County in central New York and is a city of about 15,000 population. It is the center of a fertile farming and dairying section with several large canneries and milk shipping stations. The other principal industries are furnaces, a rolling mill making wire and wire screen products; nails, drop forgings and sheet metal; a motor truck factory and the numerous smaller industries that go to make up the usual city of this size.

The traffic to and from the metal works is not especially heavy as it is handled mostly by rail, but the road tests and driveaways of trucks, together with the traffic incident to the collection of supplies for the canneries and the milk depots combine to form a considerable total tonnage. The city is also the converging point for several main arteries of travel, including the principal routes between Elmira, Ithaca, Binghamton, Scranton, Wilkesbarre and central Pennsylvania on the south and Syracuse, Auburn and the Thousand Island and Canadian territory on the north, with heavy summer tourist and year-round truck traffic.

View of Church St. Black Base Pavement on Gravel Soil, Laid in 1924. Photograph Taken in 1926.

Pavement Mileage.—The soils of the locality vary from a heavy clay in the hilly center section of the city to a more open, well drained, sandy gravel in the surrounding flat portions. About one-fifth of the city's area and road mileage is on the clay subsoil, with the remaining four-fifths on the better material. There are 45 miles of streets in the city of which 25 miles carry a surfacing of some sort. This 25 miles is as follows: 13 miles of pene-

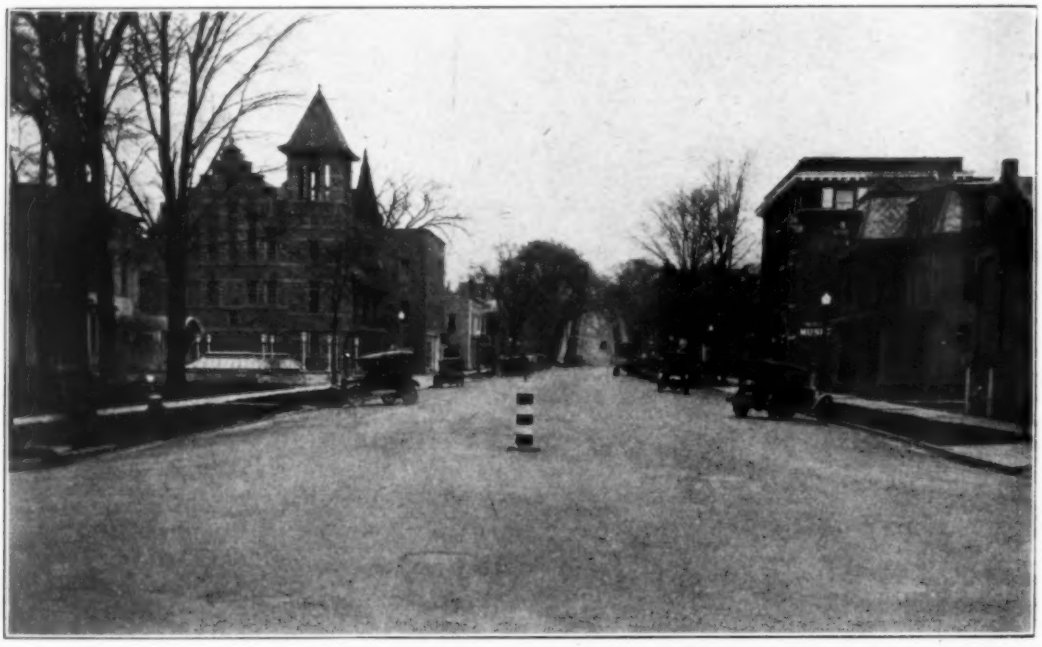
tration asphalt macadam; 5½ miles of asphaltic concrete, 5 miles of waterbound macadam with asphaltic surface treatment and 1½ miles of brick. Naturally most of the earlier pavements were laid on the principal streets and were built of sheet asphalt on a pit-run gravel concrete, 6 in. deep and of 1 to 6 proportions.

Construction of Asphaltic Concrete Surface.—In 1922 several of these streets, totaling about 75,000 sq. yds. required surfacing. They consisted of sheet asphalt paving laid at various times from 1899 to 1905, thus being from 17 to 20 years of age. They had necessitated practically no maintenance expenditures, but had simply come to a dignified old age. Unable to award single contracts sufficiently large to assure proper prices, the Board of Public Works decided to purchase an 850 yd. asphalt paving plant. In 1922 the city resurfaced three streets consisting of about 3,000 sq. yds. The work involved the removal of the old sheet asphalt surface, minor repairs to the concrete foundation and placing a new 1-in. binder course to true up the base and a 2-in. asphaltic concrete surface course. This work was continued in 1923 and 1924 on similar streets originally built from 1899 to 1905 to the extent of 18,000 yds.

During the period of this resurfacing work a large part of the new pavements, on secondary streets, were being laid of penetration asphalt macadam on waterbound macadam bases. The cost of this macadam surface was nearly the same as for the asphaltic concrete surface. Also the supply of available coarse material for macadam was rather insufficient, while plenty of the finer grades, suitable for mixed types, were to be had. These factors indicated the use of mixed tops on macadam base for the new construction as well as the resurfacing, so that in 1923 and 1924 about 41,400 sq. yd. of new asphaltic concrete surfaces were laid on new waterbound macadam base.

Use of Black Base.—During 1924, the success attending the use of "black base" foundations in other parts of the country had attracted the attention of the local authorities and inasmuch as the conditions surrounding its manufacture and use so admirably fitted with our own, we decided to use this type of base, 4 in. deep on one street and 5 on the other streets, with 1½ in. asphaltic concrete top.

The work quickly was completed with the same force and equipment used on the other streets and it has gained great popularity with the property owners. Pleasant St., 896 ft. long, was under improvement just ten days from the first excavation to completion. For Church St., 400 ft. long, it required four days to place the "black base" and two days to place the top, the pavement being completed eight days after commencing excavation work.



View of Court St. and West Court St. Asphalt Macadam Laid in 1915. Court St. in Foreground. West Court St. Hill in Background With 13 Per Cent Grade

In addition these streets were left open to traffic each night of the period.

Costs.—Table I of typical examples for each of the various kinds of work done during the 1924 season is of interest, both for comparison of types and actual costs. It should be borne in mind that these costs cover all construction items including excavation for foundations, as well as plant operation, etc.

Slag as Coarse Aggregate.—The coarse aggregate used in the construction of both the penetration macadam and the asphaltic concrete is a high grade open hearth slag, weighing 2,900 to 3,000 lbs. per cubic yard. This slag is produced by one of the local steel mills and is of excellent quality for such a purpose, being high in toughness and of an especially gritty nature. To each box of asphaltic concrete during the mixing operation, is added a certain amount of slag dust or screenings. The addition of this fine slag gives a pavement surface that is not slippery, with the result that this type of pavement has been constructed on streets having grades as high as 15 per cent and to date there has been neither a complaint nor an accident due to this type of pavement on steep grades. As examples, the following streets are some that have fairly steep grades.

Name	Type	Year Built	Grade Per Cent
West Court	Asphalt Macadam	1915	13
Prospect Terrace	Asphaltic Conc.	1923	12
Graham Ave.	Asphaltic Conc.	1924	10
Monroe Heights	Asphaltic Conc.	1922	15

(This street has side strip of hillside brick.)

Maintenance.—Maintenance costs have been very low on all types. The following table shows the treatment accorded the older streets. Work other than oiling is insignificant.

Street	Built	Maintenance
Grant St.	1911	Oiled 1924
Hubbard St.	1910	Oiled 1919
Railroad Ave.	1913	Oiled 1923
Church St.	1915	Oiled 1920
West Court	1915	None*
Court St.	1915	None

*No maintenance whatever, 13 per cent grade. Heavy traffic account construction of large public building.

Analyses of Asphalt Used.—Petroleum asphalt has been used entirely in the penetration macadam work, and for the mixed types as well, except for the work done in 1922 when other material was used. The usual specifications governing asphalt materials for such work, were maintained with penetration, 100G-5 sec., 77 F., averaging 63. Average analyses of the various mixtures are as follows:

Mesh No.	Top Passing	Binder Passing	Base Passing
Bit.	8.0	7.0	6.0
200	8.0		
80	18.0		
40	16.5		
10	12.0		
4	11.5	3.0	24.0
2	17.0	55.0	42.0
1¼		35.0	28.0

The mixtures were all manufactured in the municipally owned plant erected in 1922. This plant was rated by the manufacturers at 850 sq. yds. of 2 in. sheet course. The maximum daily yardage placed was 1,175 sq. yd. per 8-hour day, including all losses.

The work for the 1925 season, including one of the heaviest traveled streets in the city, consisted entirely of "black base" construction except that waterbound macadam base was used to a slight extent to dispose of whatever large size aggregate accumulated. In addition a considerable yardage of old brick pavement has been salvaged through the use of a hot-mixed binder and top.

Street Repairs at Night

For the past 12 months the city of Westminster, England, has had a force of men working nights on street repairs that the city engineer considered it desirable to handle without delay. The city engineer reports, according to Roads and Roads Construction, London, that very useful work has been carried out by the gang during the past twelve months, and that it is undoubtedly of great advantage to be able not only to carry out certain repairs continuously day and night, but also in many cases to carry out small repairs entirely during the night. These facilities, combined with the use of rapid hardening cements, have made it possible considerably to expedite many of the smaller repairs and thus minimize obstruction.

Table I—Comparison of 1924 Asphaltic Construction at Cortland, N. Y.

Street	Old Type	New Type	Area	Cost per Yd.	Remarks
Church St.	None	5 in Black Base 1½ in. Asph. Conc. Top	1,669	$2.05	12 in. excavation
Pleasant St.	None	4 in. Black Base 1½ in. Asph. Conc. Top	2,180	2.52	All hand excav.
Bartlett Ave.	None	6 in. Mac. Base 1 in. Binder 1½ in. Top	2,577	2.51	Steam Shovel excavation
Broadway	None	Same as Bartlett Ave. 6 in. Mac. Base 1 in. Binder 1½ in. Top	2,758	2.56	Extra interest charges account for difference
Clinton Ave.	Sheet Asp. on conc. base	1 in. Binder 1½ Asph. Conc. top on old Conc. Base	11,084	1.66	Includes removal of old top, repairing base, replacing broken curb and gutter. Binder and top only $1.21 per sq. yd.

Motor Vehicle Statistics

Registrations, Revenue and Gasoline Taxes for 1925

Some interesting information on motor vehicle registration and revenue is given in the April issue of Public Roads, a publication of the U. S. Bureau of Public Roads. The statistics show that 19,954,347 motor cars and trucks were registered in 1925, of which 17,512,638 were automobiles and 2,441,709 were motor trucks and tractors. Included in the grand total of motor vehicles were 145,530 taxis and 57,826 busses. The grand total of motor vehicles registered for 1924 was 17,593,677, or 13.4 per cent. less than the 1925 registration.

The total gross receipts from motor vehicle registration fees, etc. for 1925 was $260,619,621. The sum was expended as follows:

Collection and administration	$ 11,992,747
For state highways	177,706,587
For local roads	48,396,471
For State road bonds	19,124,014
For other purposes	3,399,802

The total earnings from the gasoline tax in 1925 was $146,028,940. Of this $102,065,216 was expended on state highways and $32,721,704 on local roads. Data on the gasoline tax rates and collections are shown in the accompanying table.

---

24 Hour Test for Concrete.—During the current year the following research projects will be in progress at the Kansas State Agricultural College: (1) Wind resistance of motor vehicles. (2) Abrasion tests of concrete. (3) Twenty-four hour test strength of sand for concrete (using Lumnite cement).

The first two projects have been in progress for some time, while the third project is new.

Gasoline Taxes for 1925 and Their Distribution

States	Gross tax assessed, prior to deductions of refunds	Exemption refunds: (Deduct from gross tax)	Total tax earnings on fuel for motor vehicles	Disposition of total tax earnings: Collection costs	Construction and maintenance of rural roads: State highways	Construction and maintenance of rural roads: Local roads	For other purposes	Tax rates, 1925: Cents per gallon: Jan. 1	Cents per gallon: Dec. 31	Date of rate change	Net gallons of gasoline taxed and used by motor vehicles	Estimated additional gallons (not taxed) used by motor vehicles
Alabama	$3, 140, 802		$2, 140, 802	$9, 461		[1] $2, 131, 341		2	2		107, 060, 092	
Arizona	1, 033, 531	$179, 600	855, 951		$427, 976	427, 975		3	3		28, 531, 666	
Arkansas [2]	3, 260, 539	280, 199	2, 950, 360		1, 357, 360	[3] 1, 593, 000		4	4		73, 786, 003	
California	18, 150, 387	1, 193, 598	14, 956, 789	7, 393	7, 229, 248	7, 229, 248	[4] $490, 000	2	2		747, 636, 442	
Colorado	1, 091, 531	30, 585	1, 060, 946		980, 473	980, 473		2	2		97, 877, 856	
Connecticut	1, 908, 809		1, 908, 809		1, 908, 809			1	2	July 1	122, 230, 292	
Delaware	350, 599	8, 499	342, 081					2	3		17, 104, 050	
Florida	7, 857, 507		7, 857, 507	6, 000	5, 549, 978	2, 101, 529		3	4	June 6	210, 238, 517	
Georgia	4, 416, 824		4, 416, 824	4, 200	1, 641, 248	1, 266, 668	[5] 1, 398, 608	3	3½	Aug. 26	138, 802, 153	
Idaho	932, 064	36, 621	895, 443	9, 466	885, 977			3	3	Mar. 1	30, 800, 330	
Illinois	None.							0	0	No tax.		530, 584, 340
Indiana	7, 832, 462	179, 413	7, 653, 049	12, 436	5, 200, 637	2, 439, 976		2	3	Apr. 1	272, 980, 870	
Iowa	3, 568, 184	63, 069	3, 505, 115	5, 520	1, 151, 144	2, 302, 280	[6] 46, 162	0	2	Apr. 16	175, 255, 740	51, 700, 350
Kansas	3, 000, 253	95, 059	2, 905, 194		2, 905, 194			0	2	May 1	145, 259, 690	52, 911, 710
Kentucky	3, 041, 580		3, 041, 580		3, 041, 580			3	[7] 3		101, 385, 310	
Louisiana	2, 339, 543		2, 339, 543		[8] 2, 339, 543			2	2		116, 970, 150	
Maine	1, 283, 874	15, 536	1, 268, 348	5, 595	[9] 1, 262, 753			1	3	July 11	56, 513, 741	
Maryland	2, 022, 986	45, 950	1, 977, 036	2, 500	[10] 1, 570, 629		[11] 394, 907	3	2		98, 851, 813	
Massachusetts	None.							0	0	No tax.		274, 615, 025
Michigan	8, 712, 392	506, 314	8, 256, 078	41, 358	[12] 6, 664, 720	[12] 5, 500, 000		0	2	Feb. 1	411, 803, 894	19, 656, 370
Minnesota	3, 980, 262	125, 362	3, 863, 900		3, 863, 900			0	2	May 1	190, 464, 097	57, 908, 930
Mississippi	2, 494, 274		2, 494, 274	1, 800	[9] 1, 224, 976	[9] 1, 265, 715	[13] 83, 783	3	3		83, 142, 469	
Missouri	4, 294, 070	74, 955	4, 199, 115	33, 429	4, 135, 686			2	2	Jan. 1	207, 955, 474	
Montana	674, 710		674, 710		709, 207	371, 080	[13] 293, 413	2	2		33, 735, 497	
Nebraska	2, 202, 256	8, 431	2, 193, 802	4, 963	2, 188, 839			0	2	Apr. 1	109, 690, 122	36, 570, 900
Nevada	315, 446	16, 741	318, 705		159, 353	159, 352		2	4	do	8, 850, 407	
New Hampshire	716, 140	9, 068	707, 072		707, 072			2	2		35, 353, 585	
New Jersey	None.							0	0	No tax.		249, 636, 220
New Mexico	587, 356		587, 356	28, 868	[9] 310, 488			1	3	Mar. 17	20, 490, 892	
New York	None.							0	0	No tax.		713, 256, 520
North Carolina	6, 238, 598	155, 130	6, 082, 378		6, 082, 378			3	4	Feb. 23	161, 371, 522	
North Dakota	648, 416	13, 000	634, 416		224, 095		[14] 410, 321	1	1		64, 041, 557	
Ohio	9, 133, 785	123, 835	9, 009, 950		[9] 4, 954, 475	[15] 2, 252, 487	[16] 2, 702, 985	0	2	Apr. 16	450, 497, 522	90, 500, 500
Oklahoma	5, 143, 517		5, 143, 517		3, 351, 898	1, 791, 619		2½	3	Mar. 23	176, 753, 177	
Oregon	3, 055, 151	156, 098	2, 900, 053	6, 353	2, 902, 542			3	3		99, 999, 535	
Pennsylvania	8, 372, 798		[17] 8, 372, 798		3, 126, 819	2, 105, 917	[17] 3, 110, 062	2	2		414, 026, 490	
Rhode Island	352, 357		318, 357		318, 357			0	1	Apr. 29	31, 825, 668	3, 576, 840
South Carolina	3, 870, 598	5, 185	3, 865, 403		2, 186, 152	1, 512, 889	[18] 166, 362	3	5	Mar. 23	93, 962, 562	
South Dakota	2, 122, 406	274, 808	1, 847, 598		1, 847, 598			2	3	Mar. 10	64, 024, 928	
Tennessee	3, 407, 886		3, 407, 886	22, 788	3, 385, 118			2	3	Feb. 9	122, 000, 080	
Texas	4, 641, 784		4, 641, 784		3, 481, 338		[19] 1, 160, 446	1	1		464, 178, 427	
Utah	1, 094, 006		1, 094, 006	3, 730	[20] 1, 060, 254			2½	3½	Apr. 1	32, 217, 216	
Vermont	592, 272		592, 272		[9] 592, 272			1	2	Feb. 26	25, 965, 167	
Virginia	3, 965, 317	161, 166	3, 701, 851	5, 804	2, 464, 231	1, 232, 116		3	[21] 3		123, 295, 585	
Washington	3, 205, 114	184, 302	3, 020, 812		3, 020, 812			2	2		151, 040, 595	
West Virginia	2, 222, 329	35, 500	2, 186, 729	7, 500	[22] 2, 179, 229			2	3½	July 1	76, 331, 050	
Wisconsin	4, 135, 469	123, 793	4, 011, 676	10, 000	4, 021, 676			0	2	Apr. 1	201, 583, 789	48, 830, 960
Wyoming	460, 972	4, 675	456, 297	228	456, 069			1	2½	do	20, 746, 058	
District of Columbia	896, 598	6, 979	889, 598				[23] 889, 598	2	2		44, 479, 898	
Total			146, 028, 940	217, 393	102, 065, 216	32, 721, 704	11, 024, 627	Av. 2.26			6, 457, 783, 284	2, 131, 068, 765

[1] For maintenance only.
[2] In addition $438,436 collected as motor oil tax at a rate of 10 cents per gallon.
[3] Includes $671,240 payments on county road and bridge bonds.
[4] Delinquent taxes uncollected not disposable in 1925.
[5] To State treasury.
[6] Unaccounted for; probably delinquent taxes.
[7] Tax increased to 5 cents effective February 21, 1926.
[8] For maintenance only.
[9] Includes $282,913 for maintenance.
[10] For maintenance and reconstruction.
[11] For maintenance of Baltimore streets.
[12] Includes $3,000,000 for interest and retirement payments on State road bonds.
[13] Payments to counties on State award highways.
[14] For sea-wall in Harrison County.
[15] For State general fund.
[16] Maintenance of municipal streets.
[17] Includes $70,000 paid-in delinquent taxes of former years.
[18] Covers part of first four months of year only, as new law excludes State general fund from share in gasoline tax fund.
[19] For free school fund.
[20] Includes $460,000 payment of interest and to sinking fund on State road bonds.
[21] Tax increased to 4½ cents effective Mar. 11, 1926.
[22] Includes $1,530,463 payment of interest on State road bonds.
[23] For improvement and repair of Washington streets.

Economics of Highway Transportation

A Paper Presented April 22 at the Annual Convocation of the Western Society of Engineers

By HENRY R. TRUMBOWER
Economist, U. S. Bureau of Public Roads

The important types of land transportation are steam and electric railway transportation and motor vehicle transportation over the highways. Highway transportation is the older type. In the early days of this country the people were wholly dependent upon the transportation afforded by the highway and upon water transportation, inland and coastal. When canals made their appearance it was believed by many that the canal and the highway should be and remain the principal means of transportation for many years to come. It is now almost a hundred years since the first steps were taken along the lines of railroad development. The venture proved such a success that it was not long before those who had vision could see that both the canal and the highway were doomed as the agencies involving the transportation of persons and property for long distances. The canal dwindled in importance and finally its use reached the stage where the canal could no longer be considered as an important factor in our transportation economy. In most cases the canals were abandoned and allowed to go into decay.

The advent of the railroad also checked the relative importance of the highway. To be sure, the highway did not go the way of the canal, but its significance as a long distance carrier waned so that it was not regarded as being more than a local transportation agency. The highway had been looked upon as a necessary feeder to the canal. When the railroads were built they supplanted the canal and so the highway was properly regarded as the necessary feeder to the rail lines. Local travel between towns and cities only a short distance apart still sought the highways—though after the advent of the electric railway and the electric interurban lines much of this so-called suburban and interurban business was diverted from the highway, also a part from the steam railroad, to the electric lines which were capable of conducting both a passenger and a freight business.

Relation Between Railway and Highway.—In discussing the relation between the railway and the highway in this country and in England a noted English economist[1] pointed out this essential difference. In England practically all the highways had been developed and built prior to the time of the advent of the railroad; in this country, except in the old and well settled sections of the eastern States, the railroads came first and highways were later laid out and built leading off in most cases from points on the railroads to the interior country. Except for the eastern section of the country highway transportation for the most part did not assume any of the long distance aspects which characterized the English and continental systems of highway transportation. The railroad developments and extensions to a large extent became the determining factors as to the settlement of the people and the development of industries and commerce. Sections of the country without railroad facilities were slow to be developed and settled in that population tended to follow the construction and extension of railroad lines.

This condition where the railroad was the main agency of land transportation continued to exist till shortly after the beginning of the present century. If it had not been for the invention, development and extended use of the motor vehicle, our highways would not now occupy a much changed position in our economic life than they did during the greater part of the last century. The advent of the automobile created a new demand for the use of our roads, in that it was capable of being operated longer distances than the horse drawn vehicle and thus afforded more service. Thus a new use and a new service was furnished by the existing highways. Today instead of being a secondary transportation agency and of serving as feeders to the railroads, the highways in connection with the use of the motor vehicle furnish us with one of our main and most important agencies used in the transportation of persons and goods from place to place.

Investment in Highway Transportation.—The highway transportation system and equipment, which includes the vehicles as well as the roads, involves an investment of approximately $26,500,000. This amount can be compared with a total steam railroad investment

[1]Mrs. Sidney Webb.

of about $22,000,000,000. The street railway and interurban lines represent an investment which in 1922, according to the census reports, amounted to about $5,000,000,000. In short, we are justified in saying that the country's investment in highway transportation equals very closely the reported investment of $27,000,000,000 in all steam railroad and electric railway property in the United States. The figures used in connection with these railroad investments are based on government reports and on census figures. The highway and motor vehicle figures can at the best be but an estimate based on the knowledge we have of the number of motor vehicles in use and of the amount and character and costs of improved highway mileage of the country.

At the end of 1925 there were 20,051,276 motor vehicles in use in the United States; 17,597,702, or about 88 per cent were passenger cars, and 2,453,574, or 12 per cent, were classified as trucks. The investment in these vehicles can be estimated as amounting to $18,551,934,832. This estimate is based upon an average cost of $866 per passenger car and an average cost of $1,350 per truck which were the actual average retail selling price in 1925. To arrive at the total investment it does not appear unreasonable to use these figures and apply them to the total number of vehicles in use. As a matter of fact this estimate is rather conservative in that the average selling price of motor vehicles has been on the decline since the year 1920, when the peak of average prices was reached. The prices between 1918 and 1920 were also higher than the 1925 average. To say, therefore, that the passenger cars and trucks used at the present time cost the people of the country 18½ billion dollars is putting this investment at a minimum figure. The road or highway surfacing, as it exists today, not including any expenditures for city streets and omitting any right of way values, may be estimated as representing an investment of about 8 billion dollars. The per capita investment in motor vehicles, according to these estimates, amounts to $161; the per capita investment in improved highways $69; the total investment in highway transportation of $230 per capita as compared with the investment in all the steam railroads and street railways about $235 per capita. The country's total investment in railroads, steam and electric, and in highway transportation amounts to about 53 billion dollars. This is only one billion dollars less than the total value of all the farm land in the United States according to the 1920 census. Reduced to a per capita basis, the average investment in railway and highway transportation facilities amounts to about $465 per capita.

This transportation property and equipment is all privately owned and operated with the exception of the highways which are built and maintained at public expense. This is our big experiment in public ownership. These investments in transportation agencies are owned, 15 per cent by the public and 85 per cent by private individuals and corporations. The corporate ownership field is largely restricted to the steam and electric railways; the motor vehicles are all privately owned and operated except for the small number of vehicles owned and operated by corporations engaged in furnishing some form of common carrier service.

Horse Drawn Vehicles.—In order to have a complete picture of highway transportation mention should be made of horse drawn vehicles. The traffic counts which have been made recently show that the horse and wagon have almost wholly disappeared from the main travelled rural highways. The horse and buggy are rarely seen; horses used in transporting heavy loads are still encountered from time to time drawing agricultural products from the farm to the market. But even here the motor truck is rapidly taking the place of wagon hauling. Although the production of the principal crops of the United States increased 13 per cent from 1900 to 1924, the number of horses on farms was approximately the same in 1924 as in 1900. The following tabulation shows this change in the number of horses found on farms:[2]

1900	18,267,020
1910	19,833,113
1920	19,767,161
1923	18,627,000
1924	18,263,000

Horses, other than those on farms, decreased in number very much more: in 1900 there were 2,936,881 horses in this class and in 1910 the number had risen to 3,182,789; by 1920 it had gone back to 1,705,611. Since 1900 the number of horses in cities and towns had fallen so that in 1920 there were 58 per cent of the number of horses found in 1900. The use of the horse naturally decreased much more in the cities than it did on farms. Although tractors are used to a considerable extent on the farms, there still are a great many farming operations which are carried on with horses. Much of the farmer's road work, however, is now done by motor vehicle. The large number of automobiles registered in the strictly agricultural states tends to prove this.

Motor Truck Saves Time in Haulage.—With the increase in wages paid to hired men and the added difficulty of securing and retaining farm labor the use of the truck in hauling agricultural products from the farm to the

[2]U. S. D. A. Statistical Bulletin No. 5, January 1925—Horses, Mules and Motor Vehicles.

market has become important. The deciding factor is the saving in time which the motor truck makes possible and also the greater operating radius of the motor vehicle. An investigation of the elapsed time consumed by using horses and wagons and motor trucks showed that it took a horse drawn wagon 7.5 hours to make a round trip from farm to market a distance of 10-11 miles; with motor truck it took only 2.4 hours to make a round trip. The motor truck did the same amount of haulage in one-third of the time. Another observation showed that for an 18-19 mile trip it took 11.2 hours to make the round trip with horse and wagon and only 4.1 hours to make it by motor truck. The saving in time in this case was 6.1 hours and the time consumed by motor truck was only 36 per cent as great as that consumed with horse and wagon. Economies of time of this nature tend more and more to promote the use of the motor truck for hauling products by the farmers. The investigation based on a number of observations showed that it requires approximately one-third as long to make the average round trip with a truck as it does with a horse drawn vehicle and if the same size loads are hauled with trucks as with wagons the time required per ton mile will be practically one-third as much with truck as with wagon.

Horse Drawn Vehicle Practically Gone from Highway.—The traffic counts taken on state highways of Massachusetts show what the tendency has been with reference to horse drawn vehicles. The percentages of horse drawn traffic are set forth in the following tabulation:

	Per cent
1909	58
1912	33
1915	17
1918	6
1921	2½
1924	0

According to this it would appear that in Massachusetts, and there must be many states in which similar conditions prevail, the horse drawn vehicle has practically disappeared from the main rural highways. In Louisiana a traffic census, taken in the summer of 1925, showed that the motor vehicle traffic on the highways was 95.2 per cent and the horse drawn traffic was 4.8 per cent. It is not believed that there are many states which exceed this ratio of horse drawn traffic to the total. In some of the larger cities a considerable number of horse drawn trucks are still found in use in the more congested sections. On account of such congestion and of the resulting inability to use motor trucks in the most efficient manner possible this horse drawn traffic continues to exist in spite of the theoretical savings which can be calculated for motor trucks. The sections of New York and Chicago in and about the large railroad freight terminal are good examples of areas in which there is a continued use of horses in trucking service.

Passenger Carrying Capacity of Motor Vehicles.—Another interesting question is the ability of the motor vehicles of the country operated over the country's highways to serve the poeple. These 20,051,276 motor vehicles, passenger cars and trucks, are in operation and capable of operating over all of the streets of our cities and over 2,976,887 miles of rural highways in the United States. The problem of congestion of street and highway traffic arises out of the uneven distribution of traffic over the existing street and highway mileage. Certain streets in cities are obliged to carry more than their proportionate share of the traffic; likewise in the country the so-called main or trunk roads carry the preponderant share of the traffic. According to the traffic surveys which have been made it is shown that about 10 per cent of a state's highway mileage carries approximately 50 per cent of the motor vehicle traffic.

The highways of the country have become, in a sense, the primary passenger carrier transportation agency and the steam railroads still remain the principal freight carriers. The 17,597,702 passenger motor vehicles, based upon an average capacity of 4 persons per car, represent a total passenger carrying capacity of 70,390,808 persons. More than half the country total population can be carried at one and the same time by the existing number of passenger automobiles. If we assume that each of these passenger cars are operated an average of 5,000 miles a year and that 2½ passengers are the average number of passengers carried per car, we arrive at a total passenger automobile mileage of 219,971,272,000 miles. A large part of this passenger mileage is produced wholly over city and town streets. Facts have not yet been developed which show accurately what proportion of this estimated passenger mileage is produced on rural highways and what part is to be credited to city streets. An estimate that one-half of the total passenger car milage is found on the rural highways appears, however, to be conservative from every point of view. If we make this apportionment we arrive at a figure of 109,985,636,000 passenger miles as the annual passenger mileage carried by the highways of the country. In 1925 it is reported by the Interstate Commerce Commission that the total passenger mileage of Class I railroads amounted to 35,963,862,000 passenger miles. It is, therefore, safe to estimate that automobiles of the country carry approxi-

mately three times as many passengers one mile over the rural highways as the steam railroads carry.

The electric railways are said to produce about 13,000,000,000 passenger miles. When these are added to the passenger mileage of the steam rialroads, we get a total of 48,963,862,000 passenger miles as against a total of 219,971,272,000 passenger miles produced by automobiles over both city streets and rural highways. This demonstrates clearly that the automobile is our principal passenger carrier.

The passenger carrying capacity of the railroads is limited to 41,399 passenger cars and coaches with a total capacity of 2,612,056 passengers. The passenger carrying capacity of the automobiles is 60,390,808, or almost 30 times as great as the steam railroads' passenger carrying capacity. The electric railways have in service approximately 100,000 passenger cars which have an estimated passenger capacity of approximately 4,000,000 passengers. When this passenger capacity is added to that of the steam railroads it is still evident that the automobiles of the country have by far the greatest passenger carrying capacity of any of the transportation agencies.

Freight Carrying Capacity of Trucks.—When a study of the freight service is made a different result is seen. The 2,453,341 motor trucks in use have an average carrying capacity of 1¼ tons. Approximately 82 per cent of the trucks are estimated to be of one ton and less capacity, which indicates that the small capacity truck predominates. The total freight carrying capacity of these trucks, therefore, amounts to 3,066,676 tons. The freight cars, of all kinds, operated by and over the steam railroads of the country number 2,547,169. The total capacity of these railroad freight cars which are in service is reported to be 111,450,034 tons. It appears, therefore, that the total motor truck capacity is but 2.8 per cent of the freight carrying capacity of the railroads. How much freight these trucks actually carry can not be ascertained definitely nor can it be readily estimated. If we assume 10,000 miles as the average annual milage per truck and apply this milage and the 1¼ ton average capacity to the total trucks in use we arrive at a total capacity milage of 30,666,676,500 capacity ton miles. This figure is far from the actual ton miles produced. The various traffic surveys made thus far show that only 2/3 of the trucks operating over the highways carry loads and that these loads average about 80 per cent of the capacity of the trucks. When adjustment is made for these facts it is seen that the estimated ton mileage of motor trucks is reduced to about 16,355,526,667 ton miles. The total freight ton mileage of the steam railroads was reported to have been in 1925—414,139,835,000 ton miles. The estimated ton mileage produced by the motor truck is, according to these figures, about 3.8 per cent of the total freight ton mileage of the railroads of the country. To just what extent this ton mileage was produced over our rural highways is difficult to tell. If we assume that half of the motor truck mileage is produced over city streets and half over rural highways it would appear that a fair estimate of the services rendered by motor trucks over rural highways is about 8,000,000,000 ton miles. This is about 1.9 per cent of the ton milage produced by the railroads in 1925.

Highways Essentially Passenger Carriers.—These estimates indicate clearly that the highways are essentially passenger carriers and the railroads are still the important freight carriers. There is no doubt that a very considerable number of the passengers carried over the highway by automobile are persons who would avail themselves of the railroad service if motor vehicle transportation did not exist. How large this number is can not be definitely ascertained. About a third of the passengers riding in automobiles on the rural highways are on business, the remainder may be classed as non-business users of the highways. A large part of the number who are using the highways for business purposes would no doubt use railroad facilities, either steam or electric to carry on their business activities, if these highway facilities did not exist. It may be said that a small number of those riding on the highways for pleasure or recreational purposes would travel by railroad if automobile transportation were denied them. Those traveling by busses are mostly all engaged in business and almost all of these would go by railroad. But these are the smallest number of persons traveling over the highways by automobile. In a Louisiana traffic count it was shown that 93 per cent of the highway passengers traveled in privately owned and operated automobiles and 7 per cent used motor busses.

Railway Passenger Mileage Decreasing.—The passenger mileage on the railroads has been decreasing when compared with the maximum attained in 1920. The Class I steam railroads of the country that year produced 46,848,668,000 passenger miles; in 1925 it stood at 35,963,862,000 passenger miles, but that figure is higher than it was any year prior to 1917. The per capita passenger rail mileage has been greatly increased since 1890. The average passenger mileage per capita in 1890-99 decade was 192 miles; in the 1900-09 decade it was 276 miles; in the period 1910-16 it was

345 miles; from 1917 to 1920 it averaged 423 miles (this was during the war and in the years immediately thereafter). During the six year period beginning with 1920 and ending with 1925 the total passenger mileage per capita was 348 miles. This is practically the same amount of passenger transportation per capita as existed in the 1910-16 period when the per capita mileage was 345 miles.

In the absolute number of passengers carried there has been a great decrease. In 1925 the railroads carried 886,650,000 passengers as against 1,269,912,000 passengers in 1920 which was the largest number the railroads ever carried in one year. The number of passengers carried in 1925 was less than that found in any year since 1908 when it was 890,009,000. In this period, however, the average journey per passenger increased from 32.86 miles in 1908 to 40.56 miles in 1925. In 1920 when the largest number of passengers were carried the average journey per passenger was 37.30 miles. During this whole period there has been an almost steady increase in the average length of the journey of each passenger by railroad. From 1908 to 1925 it increased approximately 8 per cent. There is no doubt that the automobile has been the cause of the reduction in the number of passengers carried by the railroads. This reduction has in the light of those figures taken place largely in the local passenger traffic. These figures cannot be made to tell the whole story in a statistical fashion because it must also be observed that in this period the commutation business of the railroads increased vastly, at least in the densely populated sections of the country. This commutation business is all short distance traffic.

The passenger traffic by motor vehicle can be grouped into three classes; (1) the passengers who used to travel by horse drawn vehicles, which are the smallest in number; (2) the pasengers who are taken away from the steam and electric lines which form a substantial number; and (3) those who are traveling over the highways by automobile who otherwise would have stayed at home. This last class appears to be by far the largest number. This latter statement, I believe, is borne out by the fact that the railroad passenger mileage per capita averaged 348 miles during the past six years, and that the average automobile passenger mileage on the rural highways is estimated to have been about 950 miles per capita. It stands to reason that a large part of this may be considered, in the language of the traffic man, as "new business."

Railway Freight Traffic Increases.—The per capita passenger mileage produced by the steam railroads remains practically stationary but in case of freight traffic a great increase is observed. The freight ton miles in the decade 1890-99 were 1,355 per capita; in the decade 1900-09 they were 2,247 miles; in the period 1910-16 they were 2,983 miles per capita, and in the period 1917-20 they were 3,830 miles per capita. In the six year period 1920-25 the average freight ton miles were 3,468. The passenger mileage per capita had increased from 276 miles in the 1900-09 decade to 348 miles in the period 1920-25, or 25 per cent. The per capita freight ton mileage increased from 2,247 ton miles in the 1900-09 decade to 3,468 ton miles in the period 1920-25, or 53 per cent. This indicates a much greater increase in the freight ton mileage than in the passenger mileage per capita. But going to the 1890-99 decade we find that the passenger mileage per capita increased 44 per cent in the 1900-09 decade over the previous decade and the freight ton mileage per capita increased 66 per cent. The tendency for the freight ton mileage to increase faster than the passenger mileage was noted even at that time before motor vehicle competition became a part of the picture.

Long distance motor truck traffic is not encountered to a great extent on our rural highways. The average trip mileage in all of the sections of the country where traffic surveys have been made is relatively short so far as the motor truck is concerned. The average motor truck haul ranges from 23 to 26 miles; 40 per cent of the truck movements on rural roads are less than 10 miles in length; 76 to 81 per cent of the trucks are operated over routes less than 30 miles in length. Not more than 2 to 4 per cent of the trucks operating over rural highways travel over 100 miles.

There was a time when the motor truck enthusiast had visions of the motor trucks actually superseding the railroads as carriers of freight. It was believed that that time was close at hand. According to the economic order of things this may be put down as very nearly impossible and impracticable. To carry the goods hauled by a freight train of 50 cars, 50 tons average capacity, it would take a fleet of 500 5-ton motor trucks. A freight car of 50 tons capacity costs about $2,000; motor trucks carrying 50 tons would cost approximately $50,000. A crew of about 6 men will conduct the operation of a 50-car freight train whereas it would take 500 drivers to drive the trucks required to haul the equivalent amount of freight hauled by the freight train. Although there are 5 employees engaged in railway supervisory and maintenance work for every one engaged in actual train operation service, even with 30 men's wages charged against operating a train, the labor cost is still

way below that which would have to be paid to move the same quantity of freight by motor truck. Other comparisons as to mileage, etc., could also be made, but enough has been shown as to why the motor truck can not be considered a serious competitor of the railroads in the moving of freight over long distances.

Motor Trucks Distinct Field of Service.—The motor truck's distinctive field of service is in short haul area where pick-up and delivery service is essential. The commodities hauled are primarily foodstuffs and perishables; about 40 per cent of the traffic consists of vegetables, fruits, milk, butter, agricultural produce, and truck crops. This is really an element of market distribution. On the railroads the products of agriculture and of animals comprise about 11 per cent of the total tonnage. Another significant movement by truck is the hauling of building materials, gravel, crushed stone, rock, and lumber. These are all short distance movements usually from a yard or quarry to the point where they are being used.

Where so-called long distance hauling by truck takes place it is usually found that it consists of specialty hauling, such as furniture, or it consists of commodities where time is more essentially a transportation element than costs.

The annual costs of conducting our highway transportation are naturally of great interest. The reports and cost statements filed by operating companies show what those transportation charges amount to for a year's period on the railroads. Similar records are wanting so far as highway transportation is concerned. With almost as many individual owners and operators as there are motor vehicles it is impossible to arrive at an actual and accurate cost figure. Furthermore, the highway expenses are costs which are in the first place met out of public funds. The public treasury in turn is reimbursed through special fees and charges levied upon the users of the highways and through general property and other taxes.

Motor Vehicle Operating Costs.—A statement has recently been made that the operation of motor vehicles costs the American public $14,293,000,000 a year.[3] The estimated expenditures and costs in that statement are grouped under eleven items. Such annual costs would amount to $700 per motor vehicle, and if an annual mileage of 5,000 miles per vehicle is assumed it would result in an average cost of 14 ct. per motor vehicle mile. The operating cost data which have been secured from various sources indicate that 14 ct. per mile is excessive, as an average cost per mile, including interest depreciation, maintenance, etc. It is generally believed that an average of 10 ct. per mile is a figure which can be more readily substantiated by cost figures. One of the fundamental criticisms which can be made of this $14,000,000,000 estimate is that there is included an estimated figure for annual interest charges and also the sales price of all motor vehicles and accessories sold during the past year. This results in a duplication and does not reflect a true conception of annual operating costs. An estimate of about $10,000,000,000, a year it may be asserted, covers the operating costs of the country's 20,000,000 motor vehicles. This is based on the average figures of 10 ct. per mile and 5,000 miles per year. The country's annual highway expenditures amount to about a billion dollars per year. Motor vehicle transportation involves an annual cost of about $11,000,000,000.

In this connection it should be observed that the highway costs are only about 9 per cent of our total motor vehicle transportation bill. I appreciate that no estimates are included covering city street costs because they are too difficult to make If through the improvement of our rural highways the per mile costs of operating the motor vehicle can be reduced it can be regarded as an economical expenditure. The revenues of the steam and electric railways of the United States in 1925 were approximately $6,750,000,000. It would appear therefore that the transportation costs by motor vehicle are about twice as great as the money expended yearly for steam and electric railway transportation.

Revenues from Motor Vehicles.—The motor vehicles in a direct manner contribute very substantially to the revenues necessary to meet the total annual highway expenditures. In 1925 the total license fees collected amounted to $260,619,621 or $13.06 per vehicle; the gasoline taxes yielded $146,028,940 or an average of $7.28 per vehicle. The license fees and gasoline taxes for the country as a whole averaged $20.28. All of the revenues collected in this manner were used for highway purposes with the exception that 1.3 per cent of the license fees were used up for administrative purposes, and 4.5 per cent were diverted to uses other than highway. Only a fraction of one per cent of the gasoline tax was retained to meet collection costs and 7.5 per cent of it was used for other purposes. It should be noted in this connection, however, that the collective and administrative costs are not charged in every State against the motor vehicle funds but are met through other appro-

[3]Press report of Bureau of Industrial Technology. The responsibility of this organization has not been established.

priations. So these administrative and collections costs as given here to do not include such costs in all of the States.

There is a great variation in the license fees charged by the several States; the average per vehicle ranges from $2.82 in the District of Columbia to $24.79 in Oregon. It should be said, however, that in Oregon and in certain other States where the license fees are high the motor vehicle is exempted from all other taxes, State and local. There are still 11 States and the District of Columbia in which the average license fee is less than $10 per vehicle. The gasoline tax as a means of raising funds for highway purposes is used in all of the States except Illinois, Massachusetts, New Jersey, and New York. There are now two States which have in effect a tax of 5 ct. per gallon; 1 State 4½ ct.; 4 States 4 ct.; 3 States 3½ ct.; 10 States 3 ct.; 1 State 2½ ct.; 21 States 2 ct.; 3 States 1 ct.

Not enough time is available to discuss adequately the subject of highway finances and the methods and policies which are followed to produce annually the large sums of money necessary to construct and maintain the highways of the country. Let it be sufficient for the time being to point out that in addition to the above mentioned license fees and gasoline taxes amounting to over 400 million dollars, the motor vehicle owners last year paid over 140 million dollars into the Federal treasury as excise taxes upon the purchase of new vehicles, tires and accessories and that the property taxes paid upon motor vehicles have been estimated to amount to approximately $150,000,000 a year. In addition to these direct payments by motorists there are so-called wheelage taxes and special local license fees, collected in many States, which have been estimated as amounting to about $50,000,000 a year. All told the motorists through license fees and taxes may be said to pay out annually to the government about 740 million dollars which is about three-quarters of the total highway bill. It can be well believed that the taxes and the contributions which industries and business men dependent upon the motor industry and highway transportation make are enough to offset the balance of our annual highway bill. Accordingly the burden of financing our highways rests largely upon its users.

Saturation Point for Motor Vehicle Ownership.—To estimate the saturation-point of motor vehicle ownership has been a favorite in-door occupation for many who have taken an interest in the subject. The question constantly arises as to how many motor vehicles the country is going to have and what is the limit. This was discussed by Leonard P. Ayres, vice president of the Cleveland Trust Co. and one of the ablest of the country's economic statisticians, in a treatise called "The Automobile Industry and Its Future," published in 1921. "It seems clear," he said, "that nearly every family would like to own a passenger automobile, that many individuals would like to own cars in addition to the family machines, and that there are few commercial and industrial establishments that would not possess commercial cars or trucks if they could." The fundamental situation is that the ability to purchase and maintain a car is in most cases the limiting factor. In 1920 there were 9,231,941 motor vehicles registered; these were the latest figures Mr. Ayres had available. After studying carefully the length of life of a car, the average income of individuals and families, and the productive capacity of factories, Mr. Ayres concluded that "the use in the near future of anything like twice the present number of motor vehicles seems most unlikely." At the end of 1925, within five years, the "unlikely" had come to pass; the country had in use 20,051,276 motor vehicles. The absorbing power of the public had been underestimated. The saturation-point is just as difficult to compute now as it was then. The extended use of the motor vehicle depends largely on the continued prosperity of the country and on the traffic in and about our large centers of population.

Regulation of Common Carrier Motor Vehicles.—One of the problems involved in this subject of highway transportation which is freely discussed at the present time pertains to the regulation by the public of common carrier motor vehicles. At the end of 1925 there were 27 States which regulated common carrier motor bus and motor truck operators; 7 States regulated motor busses but not motor trucks; 2 States had in effect a limited regulation of busses; and there were 12 States which did not regulate common carriers of either persons or goods. In all of the States where an attempt is made to regulate common carrier motor vehicles, the legislature defines what is meant by a common carrier. In most cases the regulation is restricted to those motor vehicles which carry persons or property for hire over definite routes between fixed termini and on regular schedules. Many of the States have taken great pains to work out a set of principles and practices relating to the regulation of this type of common carrier traffic which is increasing in its importance every day. A great many practical difficulties are encountered in the efforts to regulate as a public service facility the motor vehicle freight carrier.

Subgrade Investigations

What Is Being Done in Michigan Described in Paper Presented Feb. 17 at 12th Annual Conference on Highway Engineering, University of Michigan

By V. R. BURTON

Engineer on Special Assignment, Michigan State Highway Department

The building of cement concrete pavements in Michigan has been going on at an ever increasing rate for the past 15 years and they will probably continue to be the predominating type of hard surfaced road constructed here. The designs of pavement slab varied from the old 6-8-6 cross section with 30 ft. spacing of expansion joints on through the 7-in. and 8-in. uniform both with and without expansion joints, and finally in 1924 to the present variable sections of 10-8-10, 9-7-9 and 9-6-9 which are used according to the demands of traffic and character of subgrade. Various methods of subgrade treatment with porous subbase have been used in more or less experimental way since 1921. Different methods of underdrainage, steel reinforcement, etc., have been in use through the same period.

Construction and Service Records Available.—A vast amount of useful information is thus scattered all over the state in the service records of these different types of design. It only remained to collect and classify this information in order to make it available for use in deciding the effectiveness of the various measures adapted. All of the information concerning methods of construction, materials and workmanship were available in the records of the highway department, at least on the later state supervised jobs. It was therefore decided to start a pavement condition survey of our concrete pavements covering, if not all, at least the major part of the mileage laid to date. The selection of cement concrete pavement as the type for a study of this kind has certain very definite advantages. It is composed of a single material of nearly uniform strength throughout a cross section which remains constant in area at any particular point on the highway. The character of its structural behavior by a study of the number and location of cracks is not complicated by the use of a wearing surface of a different material, as in the rigid combination types. Non-rigid types are obviously more difficult to handle in this sort of work because no definite gradation in condition exists between perfect surfaces and serious failures. In addition to this, on unstable soils, the cross section of the original surfacing may be materially changed.

The most serious obstacle to a better understanding of the causes for the difference in behavior of pavement, laid under apparently identical conditions, in many cases is our lack of knowledge of the kind and properties of the soils they are laid on. It was felt that unless this factor were taken into account, comparisons would be of little value in a survey of this kind. It has been generally believed that most sandy soils make a good subgrade and that most clay soils make a poor subgrade. The intermediate types however with which we are more often concerned, are little understood or worse still, not even recognized. The decision was therefore made to carry on a soil survey coincident with the pavement survey for the purpose of checking up pavement and subgrade design suitable to the particular soil on which it was used.

How the Soils Are Classified.—In order to understand the basis on which all soils are classified and then mapped, a brief description of the modern method of the U. S. Bureau of Soils Survey will be necessary. The following description is taken from a report of the Committee on the Classification, Nomenclature and Mapping of Soils, Sub-Committee on the General Soil Map of the Americas by C. F. Marbut, Chairman of the International Congress of Soil Scientists.

The Soil Profile.—Soils are best defined and described where this is done in terms of the vertical section of the soil or the soil profile. This is an expression connoting the number, character, and succession of the several layers of materials encountered in examining a vertical section of the soil from the surface to a depth of several feet, usually somewhat less than ten. The layers are usually called horizons.

Kinds of Profiles.—Every mature or well developed soil consists of two master horizons, the upper of which consists of several sub-horizons, these latter constituting what are usually called soil horizons, and in this paper, the term "horizon" means these sub-horizons of the master horizon.

The upper of these two master horizons is called the solum. The lower master horizon consists of the parent rock or parent material

of the soil. It may consist of consolidated rock, disintegrated rock or unconsolidated accumulations of any character whatever. It has received no other special name than parent material. The solum or upper master horizon is the true soil.

The solum consists of material that is different in texture, color and composition from the parent material. Originally, that is, when it was first accumulated, the parent material extended from the surface indefinitely downward. The difference between the present solum layer and the parent material expresses the changes which have been brought about in the upper part of this original layer in converting it into the solum. In the following discussion, the term horizon refers in all cases, except where otherwise stated, to the sub-horizons of the solum. Profiles of nature soils in

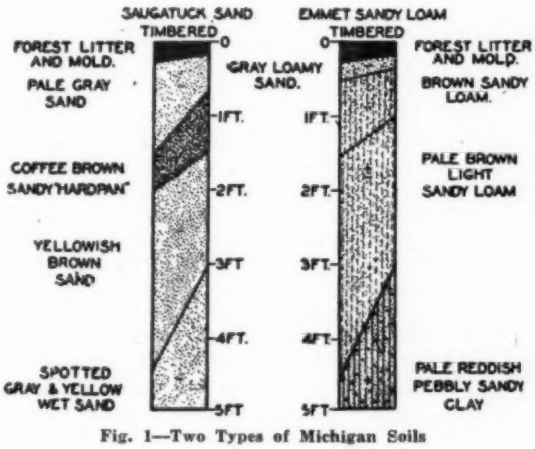


Fig. 1—Two Types of Michigan Soils

our climate consist of two main horizons, (1) an upper horizon of extraction called the "A" horizon from which clay and silt have been removed by mechanical transfer leaving them lighter in texture and (2) a lower horizon in which the clay and silt have been concentrated called the "B" horizon or horizon of concentration which is relatively heavier in texture because of the clay and silt concentration. Some chemical action also takes place particularly in the removal of carbonates. Not all of the material either mechanically or chemically removed becomes concentrated in the "B" horizon but all carbonates are removed if the soil is fully developed.

The parent soil beneath the "B" horizon is called the "C" horizon and is the original geological material, which in this state means largely glacial drifts and sediments. This has suffered no change except for the leaching of carbonates and some other constituents.

The soils in our humid climate are developed under conditions of a downward movement of moisture sufficient in amount to maintain a permanent moist condition of the soil and parent material down to the permanent water table.

Groups of Soils in Michigan.—Two main groups of soils are recognized in Michigan and are called the Northern group and Southern group, according to Dr. M. M. McCool and Mr. J. O. Veatch in Bulletin 128 of the Agricurtural Experiment Station, M. S. C. There is however a Transitional region between the two. The southern group comprises roughly all of those counties south of the north line of the Bay—Oceana tier except Mecosta and the north two-thirds of Newaygo. The Transitional Region comprises the counties between the north line Mason—Arenac tier and the southern group line except Osceola, and in addition includes southern Manistee, southwestern Wexford, all of Roscommon, Eastern Crawford and Western Oscoda, with smaller areas in some of the adjoining counties. All counties North of this Transitional Region are in the Northern group in both the Lower and Upper Peninsulas.

The virgin soils of the Northern group are characterized by an accumulated layer of organic matter which is quite thick ranging from a couple of inches to 12 in. in depth, not well decomposed and brown in color. The mineral soil underneath is always an ashy grey color from 8 in. to 12 in. in depth. The third layer or "B" horizon is brownish in color, dark at the top grading to lighter downward. This "B" horizon grades into the parent material or "C" horizon gradually.

The soils of the Southern group have a much thinner layer of forest mold usually not much over an inch in depth and is dark brown to black in color and thoroughly decomposed. The top layer of mineral soil from 1 to 4 or 5 in. in thickness is darkened by the humus mixture but below this up to about 18 in. of this "A" horizon are brown in color.

The "B" horizon is characterized by a heavier layer than the "A" in which a maximum of clay and colloids have been concentrated. The colors are quite distinct and are derived from the various oxides of iron developed by weathering.

These two main groups are further subdivided into various series on the basis of color, structure, chemical composition and thickness of the separate members or horizons in the soil profile. These series are next subdivided into types which are the units commonly shown on soils maps. Types are determined on the basis of texture of the surface soils. Texture is classification according to

size of soil particles which are from the finest up, with their diameter in millimeters,—clay 0 to 0.005; very fine sand, 0.05 to 0.10; fine sand, 0.1 to 0.25; coarse sand, 0.5 to 0.10; fine gravel, 1 to 2; gravel and stone.

The relative proportions of these various size particles determined by mechanical analysis give the textural class name, thus a sandy loam contains 0—20 per cent of clay, 0—50 per cent of silt and 50—80 per cent of sand.

Each series and type are given geographic names for identification purposes from the names of towns, counties, rivers, lakes, etc., in the locality at which the particular soil was first identified. After a soil is once identified and mapped the same soil bears the same name regardless of where found.

Two of the Bureau of Soils types found in Michigan are given. Fig. 1. First, the Saugatuck sand, is characterized by a coffee brown layer of sand at depths of 8 to 24 in. which is frequently cemented into a hard pan. Under the surface of 2 to 4 in. of forest mold is a pale gray sand from 8 in. to 18 in. thick which may be colored somewhat by the overlaying organic matter in the upper portion. The yellowish brown strata below the hard pan is fairly loose. Below this yellow brown layer a wet poorly drained soil of gray and yellow mottled sand is found. This soil is always poorly drained because of the high water table held in place by the comparatively impervious hard pan layer.

The other type shown in the Emmet Sandy Loam which is characterized by a thin layer of 2 to 4 in. of forest litter and mold underlain by a thin layer of light gray loamy sand and then into a layer of brown sandy loam grading off into a paler brown light sandy loam below. At a depth of from 3 to 4½ ft. a very much heavier layer of pale reddish pebbly sandy clay is encountered. Moisture penetrates the clay very slowly and hence a springy condition is encountered at the top of the clay layer in the sandy loam.

These two types were chosen to show the engineers interested the character of the profile work done in soil mapping and to illustrate the point that a mere surface study of soils is of little value. The two soil types shown would certainly require special drainage treatment to insure adequate subgrade support and eliminate frost heaves in pavement. It can now be understood that no such generalization as "sand is always a good subgrade" is justified.

A soil type once identified is considered the same wherever found, because similar causes have produced it. Any given parent material is subjected to the same climatic conditions and with similar topography and drainage will produce the same soil type. The recognition of this fact is a new idea to the engineer and not a very old one to the soil scientist.

The modern mapping of soil mapping and classification is little over 5 years old. The older classifications depended more on textural relations than on the relation of stratified layers due to soil making processes used at present.

Soil Studies of Value to Engineer.—The adoption of this new system of classification and mapping by profile series and type is really the agency which has made soil studies of value to the engineer. The mapping of soils according to this system for highway work will necessarily be more detailed than that required for agricultural purposes but it will be only a recognition of smaller areas of particular types rather than in greater type diversity. The work of the Bureau of Soils on the physical and chemical properties is thus made available for highway purposes although the work was conceived and carried on almost exclusively for the use of forestry and agriculture.

The adoption of the standard soil classification will enormously diminish the amount of soil testing necessary. These type soils vary throughout the state only within quite narrow limits of composition, texture and structure and once the limits are recognized and the standard soil tests made to determine their variation in soil properties only a minimum amount of further testing will be necessary.

There has been in Michigan up to the present time, about 100 different types recognized and mapped. While this may seem a large number, the task of determining their effects on pavement design is by no means the hopeless job which would confront us if every different soil encountered on a highway job had to be laboratory tested.

Certain types on the sand and of the scale will be recognized as always good pavement subgrade and certain others on the clay and will be recognized as uniformly bad. Our attention will then largely be directed to the intermediate types. The reaction of these different soils to various methods of pavement cross section, subgrade, treatment and underdrainage design is of course determined by the pavement survey of actual field conditions.

How Surveys Are Being Made.—The present survey party consists of one engineer familiar with construction methods and three assistants. Two of these assistants chain the pavement, marking at every twenty feet and painting the station numbers every hundred feet. The other assistant accompanies the engineer following the chaining party. The

engineer takes one side of the pavement and the assistant the other and cracks are located by both and sketched to scale on specially prepared cross section paper by the engineer. Any special feature of surface defects such as pitting, scaling, spalling, hair checks, etc., are all noted on the sketch. About four miles of survey can be done by this party in one day on average work.

A soil expert has been secured who is skilled in soil mapping and who follows up the pavement party using the painted stations to locate his variation lines and a strip 200 ft. wide is mapped. After the soil is mapped he again goes over the road and secures types samples which are sent to the State Highway Laboratory for routine tests. After a sufficient number of soils have been tested for variations within the type, the number of samples can be very considerably reduced.

Both pavement survey and soil survey are sent in to the main offices as fast as taken and the information transferred to the original plan. The actual sketch of the surface of the pavement is plotted to scale on the original plan scale of 100 ft. to the inch. This gives a rather small sketch but is easily readable when done by a neat draftsman. The entire story is then before the eyes of the investigator. The type of soil and depth into the soil profile to which the pavement was laid, grades, cross sections, surface and sub surface drainage, subgrade treatment and all the other details having a bearing on the problem may be seen at a glance.

Surface data sheets of the pavement survey are made up so that stretches of the road may be readily compared slab by slab with any other stretch on which comparison may be desired. These surface data sheets give slab lengths, number and kind of cracks and pavement classification according to the length of unbroken slab and area of pieces of the broken slabs, amount of scaling, hair checking, etc. If a comparison of any, pavement in Miami loam and four inch subbase of gravel and pavement on the natural Miami loam soil is desired, the information is simply taken from the surface data sheets and summarized on a summary sheet provided for the purpose.

To date 108 miles of pavement have been surveyed and 16 miles of general soil survey finished. Both surveys were started late last fall but due to extremely wet weather the progress was somewhat disappointing. The plans for 1926 include the survey of the remaining 2,000 miles on the system,—whether or not it may all be accomplished depends somewhat on the state of our finances which at the present time is to a certain extent uncertain. It is the intention to at least cover as large a variety of soils and design as possible during the coming season. Enough of the work has been done though, to show us in what ways the collecting and classifying of the information can best be done and we can enter 1926 knowing very nearly the organization and methods necessary to successfully complete the job.

French and English Main Road Costs

The population of France is about 40,000,000, and that of Great Britain 45,000,000. With mileages of main roads and numbers of commercial and other motor vehicles fairly corresponding, the costs per mile are worth noting. The following comparison is taken from The Surveyor, London. In 1925 the routes nationales cost in maintenance 242,000,000 francs, or 6,050 francs per kilometre. At par, this is nearly equivalent to £390 per mile. In 1922-1923 the cost of English and Welsh county roads was £390 per mile. If, however, we take Prof. Gavrian's estimate of the sum necessary to maintain in good order, under existing conditions, a kilometre of route nationale, 10,000 francs, this corresponds at par to £644 per mile. This may be compared with the 1925 cost of British Class I roads, £673 per mile. Class II roads cost £365 per mile, providing a suggestive correspondence with the 6,050 francs per kilometre already noted. Prof. Gavrian estimates that it will be necessary to spend a milliard of francs in the next ten years, at the rate of 1,000,000 francs a year, making the total annual expenditure on the routes nationales 500,000,000 francs, or 1,250 francs per kilometre, say, £805 per mile, which, in so far as it exceeds, say, £600 or £700 per mile, seems to represent the accumulative value of the earlier effort in the post-war improvement of British main roads.

Seeding Missouri Road Sides.—The Missouri State Highway Department, with the aid of college of agriculture experts, is adding to the road-side beauty by planting the dirt shoulders along the concrete roads, and the long fills on other types of improved state highways, with blue grass. More than 250 miles along the state highways have been seeded.

Traffic Test in Paris.—A new kind of traffic test is to be made in Paris. A street will be set aside as a traffic laboratory, in which will be conducted all sorts of tests for motor traffic to determine the cause of accidents. Various surface materials and safety devices will also be observed, as well as mistakes in driving and the most efficient control of traffic.

The Location of the Modern Highway

Effect of Alignment and Grade with Particular Reference to Michigan Conditions Described in Paper Presented February 16 at 12th Annual Conference on Highway Engineering at University of Michigan

By HARRY L. BRIGHTMAN
Engineer of Surveys, Michigan State Highway Department

The subject of highway location is affected by so many other considerations than alignment and grade that if these alone were considered one would be apt to get a distorted view of the subject. I have, therefore, taken the liberty to diverge from the strict interpretation of the title and look at the subject of location from the broader aspect. Again, I shall confine my remarks on the subject as it can be applied in Michigan. We have country ranging from the absolutely level plains to the semi-mountainous country. For the real mountainous country the same hypotheses will hold, although restricted by the nature of the country.

Aspects of the State.—The state is divided into two peninsulas of different characteristics. The lower is divided into two parts which should receive different considerations. From a line drawn from Bay City to Muskegan south the country is largely industrial except along the shore of the Great Lakes. North of that line the resort and tourist business is perhaps the country's largest asset. The upper peninsula is the semi-mountainous region of the state and the mining and resort interests are geographically so closely related and the roads are so few as compared with the lower peninsula that the problem is entirely different. We have, thereore, the combined commercial and tourist traffic in the lower half of the lower peninsula, the largely tourist traffic in the upper part of the lower peninsula and the combined commercial and tourist traffic in the upper peninsula. These three different aspects will have a bearing on the prime consideration of what the road is to be used for, and the relative values of these uses in the location of the highway.

At the time the Legislature first laid out the system of trunk highways they considered the value of the system as one which would provide farm to market roads and would incidentally connect up and make through highways from town to town. The long distance travel by auto had not come into being. If one could get from one town to the next, that was about as far as he would want to go. We now have the long auto trips but we still have the old highways (excepting such changes as have been made in recent years) and the problem becomes that of further changing, adding to and rerouting the main arteries of traffic to accomodate the new condition which has arisen. It, therefore, becomes a problem of careful picking and choosing to change these routes in the most logical manner and the relative value of these different routes must first be determined.

Engineering Considerations of Different Routes—When considering the relative values of the different routes it is as well, perhaps, to consider them first from their engineering standpoint. This will involve an accurate knowledge of the physical geography of the state. One can tell, then, immediately how best to go from one point to the next with the greatest saving in distance and with the most directness. Having, by engineering considerations, restricted the route to a certain territory, one should then apply the acid test: the opinion of the public at large; the cost of construction; the present and estimated future requirements; the traffic which the road is to carry; the connections with other trunk routes and important local roads; the alignment and grades which are permissable or desirable. So far one has considered the route from a general standpoint. Having arrived at the general conclusions, one is ready to attack the problem from the local or specific standpoint. He must then go into details; the exact alignment, the grades possible, the exact distance, the railway crossings, drainage conditions, soil conditions on which the stability of the road depends, stream crossings, crowded city or village streets, specific points of cost, right of way considerations, resort localities, lakes, public parks, etc.

9 Classes of Location Problems.—In the book of instructions for the Chief of Survey Parties called "Highway Location and Surveying," I have separated the problems of location into nine different classes which are distinct and yet are so closely related that one cannot be considered without considering some of the others. The list is as follows:

1. Locations for the betterment of grade.
2. Locations for improved alignment.
3. Locations for shortening distance.
4. Locations to secure better drainage and soil conditions.
5. Locations to eliminate grade crossings of railways, either by not crossing the railway at all or by securing the proper position for a grade separation.
6. Locations to avoid the congested streets of cities and villages.
7. Locations to avoid stream crossings.
8. Locations to avoid excessive cost of construction.
9. Locations to get to the shores of the great lakes.

Large Units for Construction.—We have made mistakes in the past by considering too small a unit for construction. We now determine two terminii which are logical division points and proceed to work between them. These points average from 50 to 60 miles apart. We then take up the problems presented by these longer units, making sure that the end connections are not overlooked. The two terminii may or may not have a road connecting them.

If there is a road and it is fairly direct but full of curves and turns and does not pass through territory which is not suitable for road building, the problem becomes one of seeing how close we can follow the old road and improve the alignment to the modern standards. If there are places of heavy earth work and steep grades we would attempt to locate so that the grades may be reduced and the amount of earth work lessened.

The work is restricted to a rather narrow area. If, however, there is no very direct road leading from one terminus to the other the investigation usually resolves itself into the study of a diamond shaped area, the two points being at the terminii and the broadest part some place in between. Within this area there may be several possibilities. It becomes the duty of the engineer to search out the country from an engineering standpoint to find a route or routes which he thinks may be the solution of the problem.

The general method of procedure should be to work from the outside to the center, gradually eliminating the impossibilities until the final two or three routes are chosen for a very careful study by means of preliminary surveys.

These surveys are often very extensive and obtain all the information relative to the physical features of the country, such as contours, stream locations, buildings, farm boundaries, hills, valleys, railways, etc., all being platted on a map of suitable size so the costs, alignment, grades and other features may be considered. The final route is chosen and placed on the map from which it is transferred to the ground by a location survey. The work is watched as the location progresses to see that the line as projected on the map fits the ground as well as was expected.

Location of New Road.—Again, if no road at all exists, the problem is much the same only much more difficult. To me, however, that is the most interesting part of location work. Usually the country is not well developed and there is more latitude allowed. In any case the engineer will be given plenty of opportunity to use all the good judgment and common sense which he possesses. After all, the final test of a change of routes is that of public opinion unprejudiced by selfish motives. This, unfortunately, is usually not available until the route is constructed and the public has had an opportunity to use the road. There is liable to be much opposition toward a noteworthy change. If the highway engineer is not several steps in advance of the general public opinion he is not functioning to the fullest extent. If no real benefit is received by the public the change of routes is certainly unjustifiable. The engineer has to keep in close touch with the public and be very sure of his opinion before proposing any radical changes. Happily, the public is being rapidly educated in the benefits to be derived from the properly located highway and they do not look with so much disfavor upon the changes proposed as they did a few years ago.

There are three things of an engineering nature which have great effect on the location of the modern highway. These are directness, local alignment and grades.

Directness.—Directness is a quality to be sought after in that it reduces the distance of travel between two points. This must be applied with caution and a thorough knowledge of the part of the country in which the road is located. In the commercial districts a direct route between two cities is very desirable. The reason is self evident. In the resort portions of the state a road which goes direct from city to city will often defeat the very purpose for which the road is built, that of taking the tourist to the points of interest which he wishes to visit. He is really in no pressing need to get from one point to the next as fast as his car will go, although to see them driving one might get that notion. In fact, if he is the true vacationist, he should be pleased to spend his time and money seeing the beauty the country affords rather than driving at top speed from one city to another. However, the people living in that section of the country as well as the tourist who is going to his home at some point far beyond use the road more in a commercial sense.

Therefore, we must so locate as to serve the vacationist by bringing the road as close to the desired beauty spot as the considerations of the local and through traveler will permit. The desired point of beauty can be reached by a side road of short length. In fact, many people desire seclusion and would prefer the main highway some little distance from their retreat. Again the topography of the resort regions is such that there are well defined lines through which a modern aligned highway can be put, which simplifies the broad study of a great expanse of country. So, after all, the direct highway is the one to build when one considers what may be the objective points to be reached by that highway.

Saftey One of Most Important Considerations.—We have looked at the alignment of the highway from the more general considerations. Let us, now, go into a little more detail. In our general study we have located about the general position and direction which the new highway will take. We have now to put the line on the ground most advantageously. In doing this one of the most important considerations is that of safety. Another item which must not be overlooked is that of the appearance. This item did not gain so much importance until the hard lines of the concrete pavement showed how easy it was to build a road which looked like the work of a novice instead of an engineer. Most people think that a perfectly straight highway would be the safest that could be built. Experience does not indicate that this is a fact. On the long tangent of a concrete pavement the driving becomes monotonous and hence more or less subconscious. The tendency is to go to sleep. The inducement to very high speeds is also very great. At night one can see the headlights of opposing cars for miles if the country is flat and for long distances if rolling. This makes driving dangerous. All these factors tend to diminish the safety of the road. In my opinion, the properly curving alignment is the most satisfactory. In the later surveys now being built as well as those being surveyed I have often broken up possible long tangents so as to avoid this situation. Yet when you drive the road you neither loose distance nor are you able to tell where the possible long tangent might have been placed.

The Section Line Road.—Let us now go back and look at the preliminary map which we made to show us all the features which we need for the final location of the center line. Let us first suppose that this map and route follow the section line road. This is, I believe, the hardest problem which the locator has to solve. The sharply defined lines of the concrete show up every little angle in the road. We try first of all to hide them on the tops of hills. Failing that, the only solution for an angle of a few minutes is to put in a very long curve, not less than six hundred feet in length. Of course, it goes without saying that we wish to follow the section line as closely as possible as usually that will do the least damage to property. Trees, buildings, and other improvements are already in place and we wish to go between them without taking them out. The long curve seems to blend with the landscape and takes away the otherwise ugly looking angle. We have some examples in this state in which this practice was not followed and the effect to one looking down the road is as though some giant had thrown the blocks of concrete and left them as they landed.

Let us now suppose that the map represents one of the many angling roads which are in the state and which follows in general the old trails made by our forefathers a hundred or more years ago. These men certainly knew their way about the country for where the old trail is followed exactly we have the real direct road which we would like to see. Of course the traffic of their day was limited to the speed of the ox cart and the angles or turns were not designed for the modern high speed traffic. They wound around to get natural grades as much as they could and followed the ridges to secure safety from Indian attacks. Yet we find, that with all their winding, we do not shorten the road much with our modern alignment. The problem here resolves itself into a process of smoothing out the sharp turns and fitting the new center line to the hills and valleys in such a way that we obtain desirable grades and alignment. One is at liberty to use all the imagination one possesses to so place the line that when the road is built it will fulfill all the requirements.

The Angling Road.—When we are studying the angling road we find that the problem is entirely different from the section line road. Here we usually have short tangents with angles varying up to ninety degrees and sometimes more. We often find that we can rearrange the old tangents and put in a long-curve which will approximate the location of the old road very closely. We have carried this mapping and arrangement of tangents to such an extent that curves of amazing length can be used. We have one curve of 4600 feet now constructed in concrete and one of 6700 feet in the process of construction. We have another laid out which is about 7600 feet in length. These could never have been located without the map.

We have come to the conclusion that the very sharpest curve to use is that of 500 feet radius, and that this should be used only when there is no possibility of a longer one. Owing to the fact that curves sharper than 5 deg.-

30 ft. are widened, which precludes the use of the finishing machine, the tendency is to make curves flatter than that. On this kind of location we do not make the tangent distance of any curve less than 300 ft which sometimes makes the degree of the curve as low as one minute for small deflection angles. As all curves up to a radius of 6000 feet are superelevated and as the warp extends a distance of 150 feet on the tangent, the distance between the ends of two curves of opposite direction should not be less than 300 ft. Where the curves are in the same direction this distance may be reduced some as the construction engineers can work out the warp so that it will be satisfactory. Where two curves reverse they should be as near the same degree as possible. Where two curves compound, the radius of the sharper should not be less than two thirds of the flatter, in order to make good riding. The use of the compound curve often solves an otherwise very difficult situation. A short curve should never be placed at the end of a long tangent. In a paper of this kind it is impossible to go into details of all the rules we have for the relation of curves and tangents. I have touched on some of the more important ones only. In general one might say that the whole thought is to make the location fit the topography and to make curve and tangent so related that the driver on the road experiences no abruptness and feels at all times that he is not coming to a situation which will imperil him because of faulty location.

The subject of vision is one that cannot be overlooked and it is related to both horizontal and vertical alignment. In order that the motorist may always see far enough ahead for safety, the road should be so aligned that a clear vision of 500 feet ahead is available. This is worked out by the long curves and the cutting away of banks which may hide the view in horizontal alignment. The vertical alignment is solved by the use of vertical curves in the grades which allow a car to be seen at a point 500 feet distant at all times. The length of these vertical curves depends entirely on the pitch of the intersecting grades. This often requires considerable study of the grades used and a careful planning of the cuts used on hill tops. When it is impossible to cut the required amount on the hill top the fills must be increased by borrowing to give the required elevation on either side of the crests of the hills.

Grades.—Vertical alignment, or grades, often make the locator use his wits to the fullest extent. In the Lower Peninsula, where the land is gently rolling, we have no difficulty in keeping the grades well below 6 per cent. In some of the hillier portions we have difficulty in keeping grades below 8 or 9 per cent. Fortunately the difficult situations occur for the most part on the less important trunks, so the steeper grades are not so detrimental. The average touring car can easily climb an 8 per cent grade in high gear, while the trucks are fully equipped with lower gears which always outlast the rest of the truck, and the heavy trucks are not used to any extent on these roads.

The question of the maximum grade to be used between two termini should be solved first. It is obvious that if there are certain grades between two terminii which cannot be reduced below a certain maximum, it would not be wise to spend excessive sums of money to secure lesser grades at intermediate points. The maximum grade for a project must be correlated with the other features of the location. There is no set maximum grade for any road in Michigan. It is desirable to obtain 4 per cent grades on the main commercial routes and 6 per cent on other routes. The rolling grade is the most economical, both from the construction and operation cost. A short grade up to as high as 8 per cent is not objectionable for the lighter traffic. For heavy traffic (trucks) these grades are difficult and it requires a very nice judgment to say when it is advisable to sacrifice alignment and distance for lower grades. The mere fact that a road is now in a certain position and all its difficulties have ben endured by the people for many years is no reason to suppose that it should always remain there. It behooves the location engineer to study these things carefully.

It is seldom possible to reduce both grades and distance by realignment. One must be very careful to see that, in securing the lower natural grade, he does not introduce enough distance (as well as poor alignment) by which extra cost is introduced which may be greatly in excess of the cost of heavy cuts required on the old line to make desirable grades. In order to determine the relation between the two a complete preliminary survey should be made and the cost compared.

A 16 Per Cent Grade.—We find some very interesting situations on some of the present trunk lines. In Benzie County we have a hill with a maximum grade of 16 per cent, a very crooked alignment and a grade crossing of a main line railway at the very foot of the hill. We are studying this situation now. It is one where we will have to find a new location in order to separate the highway and railway grades, without burying the village at the foot of the hill. We have run many traverses with levels and have even used the areoplane photographs. From the air we discovered a route which escaped us as seen from the

ground. We now believe that we now have a reasonable and economic route over these hills, for there are two of them in the same problem. There is a crossing of the Manistee River west of Cadillac where the elevation drops 400 feet in less than a mile and a half (approximately 16 per cent) which is going to make somebody scratch his head. I mentioned these to show to what trouble grades will sometimes put us.

50-Ton Loads a Probability.—This paper will not go into details as to the laying of grades after the location is made. If we could look into the future far enough we might change our ideas in regard to the location and grades on highways. I was told recently by a member of the Society of Automotive Engineers, who is engaged in the solution of the problem of the trailer for heavy duty work, that he believed that the time is not far distant when we will see loads of 50 tons or more going over the highways in regular trains of tractors and trailers. The advance in the motor world is so rapid that what we now think is the acme of perfection in road building may seem very much the opposite within a few years. The engineer can be guided only by the vision he has of what the future may bring forth and the money which he has available for the work.

Qualifications of a Good Location Engineer.—We have spoken very glibly of the locator as though he were some kind of an automaton who leaves the office and presto! he is back with the road all located. Perhaps it would not be out of place to consider what kind of man is the one who is going to do all the work outlined above. To make a good locator a man should have had some experience on railroad work in positions where he had some responsibility.

He should then proceed to forget most he has learned. This may sound peculiar, but the lessons learned in the railroad work will teach him the value of exactness and subconsciously he will be much better qualified in mind training for the work of highway location. However, that experience is becoming harder to get as the railroads are not building many new lines, at the present time.

He is handicapped by the lack of good up-to-date books on the subject of highway location to use in his college course. Probably the best books now in existence on this subject are the instruction books put out by the various State Highway Departments. I have had many of them and each attacks the problem from the angle of its particular state. Together they make a very good set of instructions.

All of this literature will be of considerable help to a man but he will have to learn most of his lessons in the actual work. He must be born with some very necessary qualifications for I doubt if he can acquire them.

To make a successful locator a man must have a very vivid imagination. He must be able to see the new road as he walks over the country he is exploring. How will it fit this slope, how will it cross that stream, how are the swamps and hills to be avoided, are only three little questions of many which he must find the answer for.

He must have a highly developed sense of direction and an exceedingly good memory of geographical locations. He must have a sort of sixth sense to keep properly correlated all the things seen on his exploring trips. He must be a student of physical geography, of geology, of petrology, and in the glaciated parts of the country a student of glacial geology. Also he should be able to name the various trees met with and know what kind of soil is their habitat.

He should be a good "man in the woods" which is no mean accomplishment. To the country boy who had a chance as a child to roam the woods this is much easier than for the city boy who never had that chance.

Last but by no means least he should have had experience of responsibility in the actual construction of the modern highway. This gives him the knowledge of what the construction work requires in the way of information turned in from which the plans are made. We have found that such men are rare birds and when one is obtained he should be paid according to his worth.

A college education is necessary for a man to take carge of a party and execute his work properly unless he is one who has had the courage to get the knowledge required by his own efforts. To the men who located the original roads of this country we should give great respect for they make very few mistakes.

One thought I wish to leave with you is that if highway engineering is to be of value, it must be thorough. Any new locations, or failures to make the needed new locations, will often fix the location of roads for many generations to come. There should be no hesitation in spending whatever is needed even if it seems all out of proportion to the cost of the actual construction work to be performed within a year or so. Government programs carry out this principal and they are often criticized for the high engineering cost but it is well worth while looking into the fututre. The engineering program must be complete or it might just as well be discarded entirely.

Economic Transportation

An Interesting Discussion in the Bulletin of the Permanent International Association of Road Congresses

By W. W. CROSBY
Formerly Location Engineer, Pennsylvania State Department of Highways

In the Bulletin (No. 39) for May-June, 1925, under the title "Highway Finance" appeared a considerable article built up from a premise phrased as follows:

"No road should be improved by the expenditure of public funds in excess of its earning capacity. The return to the public in the form of economic transportation is the sole measure of the justification for the degree of improvement."

The structure of argument erected on that footing was admirable and the conclusions alluring to accept. But unfortunately the rottenness of the foundation is so evident that distrust of the whole—even by your most friendly and credulous readers—makes one wonder at the article.

It—or a similar structure of argument—has appeared in the United States rather frequently during the past few years though not much attention to or public discussion of it has appeared here. Now that the phrase has been dignified by your publication of it, "the time is ripe, the walrus said" to attack, and, let us hope, dispose of it once and for all.

This phrase is a foundling left on the doorsteps of the highway engineer during his absence in France. Its paternity seems uncertain and not worth while discussing further here—sufficient to dispose of the phrase itself. It is a "War-Baby," born about that period when phrase-making seemed "the favorite (indoor) sport of Kings," and as an individual bears analysis or shows abilities and promise about equal to some of its contemporaries.

Let us for a moment examine the phrase bodily. It bears a decidedly commercial aspect. Some of its features suggest lineal descent from Shylock. Taken literally it might oppose the expenditure of any public funds for prospective returns from road improvement which hope has in the past been so important a factor in furthering modern road improvement and which even now cannot be discarded if we are to progress.

Again, have roads ever been built or improved "solely" "for economic transportation" except in a very few special instances? Or should that one feature control even now?

Recent highway traffic surveys from widely distributed points which include some of the most decidedly commercial highways in the world show that, at least in numbers, the commercial traffic is everywhere a small fraction of the whole use of the public highways and that "economic transportation" is one of the minor, if not perhaps still the least important factor to consider in connection with the decision of whether or not to improve a public highway from public funds.

In the United States repeated studies in various states have confirmed the following summary:

Truck traffic averages only 10 to 15 per cent of all vehicles.

Business traffic averages less than 35 per cent of all vehicles.

"These two types may be directly concerned with the economy of transportation but it cannot be said 'solely' because other considerations of comfort, convenience, time, and even pleasure, enter more or less consciously."

Purely pleasure traffic accounts for at least 65 per cent of the average of all vehicles.

To this traffic "the return in the form of economic transportation is the sole measure of justification for the degree of improvement" almost wholly to be disregarded and eliminated in the demands for public road improvement from this major fraction of the public road travelers.

That this disregard of "economic transportation" is not merely reckless waste may easily be seen. Let us look for a moment at the sources of the "public funds."

On page 97 of the same Bulletin is an article "Distribution of Costs," in which one finds immediately the following:

"The cost of building and maintaining adequate systems of highways should be distributed in an equitable relation to the benefits derived. These may be summarized as follows:

(a) Benefits to society in general, such as influence on education, recreation, health, fire prevention, police protection, the national defense, the postal service, living and distribution costs.

(b) Benefits to definite groups, such as agriculture, manufacture, labor, railroads, mining, forestry and waterways.

(c) Benefits to property served.

(d) Benefits to the road user.

"2. For the purpose of apportioning costs in relation to benefits received, all highways may be divided into two classes; first those used by the general motoring public, and second, those which perform a purely local service function.

"3. Special motor vehicle taxes should be levied and need only for the improvement and maintenance of highways used by the general public, i. e., for general highway traffic flow lines."

Enough has been quoted perhaps to show the conflict of dogmas and, it is hoped, the utter absurdity of the first unfortunate phrase. One more reference to authorities in order to finish the "mopping up":

Examination of the Proceedings of the 4th Annual meeting of the Highway Research Board of the Division of Engineering and Industrial Research, National Research Council reveals on p. 70 et. seq. a "Report of Committee on Highway Finance" (H. R. Trumbower, U. S. Bureau of Public Roads, Chairman) wherein the following statements are found:

"The average percentage of all rural highway expenditures in the U. S. A. during 1923 borne by receipts from motor vehicle license fees and gasoline taxes was 24.2 (p. 76).

"In 1923 there were five states—Massachusetts, Vermont, Connecticut, Maryland, and Rhode Island—in which the motor vehicle revenues were more than 50 per cent of the total highway expenditures" (p. 77).

"Of the $188,613,054 collected (in 1923) as motor vehicle license fees, $153,226,618, or 81 per cent was used for highway work by state highway departments. In 14 of the states 100 per cent of the license fees are turned over to the state highway departments" (pp. 86 and 87).

Evidently the functions of improved highways are not solely for "economic transportation" as signified by "earning capacity." Neither are the funds expended provided from sources proportionately to that single end.

Beside our own Nationals there are many visitors to this country who have enjoyed our modern roads and even compared favorably many of them, where "the measure of justification for their present condition in the form of economic transportation" or "earning capacity" is too small to be calculated as part of the "return to the public" such as the Columbia River Highway, the Susquehanna and Lackawanna Trails, and the Storm King Highway, to those famous older roads—the Axenstrasse or La Corniche.

Could even these latter justify their existence on the basis of the peculiar phrase under criticism?

There is a theory to the effect that if a statement is repeated frequently enough it becomes accepted as a basic fact. The theory resembles that of rights by proscription and is probably valid within limits. Therefore let us now interrupt this "acquirement by use" with the hope of preventing an establishment which would surely prove embarrassing soon. To the writer, it is shameful even now if it broadcasts the idea that the road improvement of the United States is guided solely by considerations of commerical profit.

Estimating Average Traffic

How Weekly Traffic Counts Can Be Used for This Purpose Described in Concrete Highway Magazine

Many traffic counts have been made but most of them cover short periods when the traffic is assumed to be normal. Almost invariably the census is taken during the summer months, when traffic is above the average, so that the count does not represent the true average travel on the road. The following method is suggested as a reasonably accurate means of estimating average traffic from weekly traffic counts.

The average traffic can, of course, be determined by counting every vehicle using a road during the year. But the cost of such a count would be prohibitive. If, however, in a given area, such as a state, sufficient yearly counts were made to determine the seasonal variation, then fairly accurate estimates of the average traffic on similar highways could be made from counts taken during short typical periods.

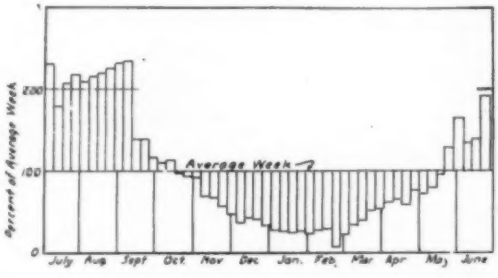


Fig. 1—Weekly Traffic in Per Cent of Average Traffic

A yearly traffic count taken from the records of a toll bridge over the Connecticut River illustrates what can be done in that connection. The Connecticut Highway Department secured the traffic census on this bridge for the period from July 1st, 1920, to July 1st, 1921. The bridge is on the Old Saybrook-Old Lyme Road, which is a part of the shore route between New Haven and New London. This road is a direct route between New York City and the summer resorts on the north and therefore carries a heavy tourist traffic, with extreme seasonal variations.

The data have been summarized in charts the first of which is the most important. Fig. 1 shows the relation, in per cent, of each week in the year to an "average week," obtained by dividing the total number of vehicles for the year by 52. The average traffic over a similar

road may be estimated from this graph if the traffic count for any week is known. Suppose, for example, that a census taken during the week beginning August 1st showed a total of 21,000 vehicles. The graph gives the traffic that week as 210 per cent, the average being

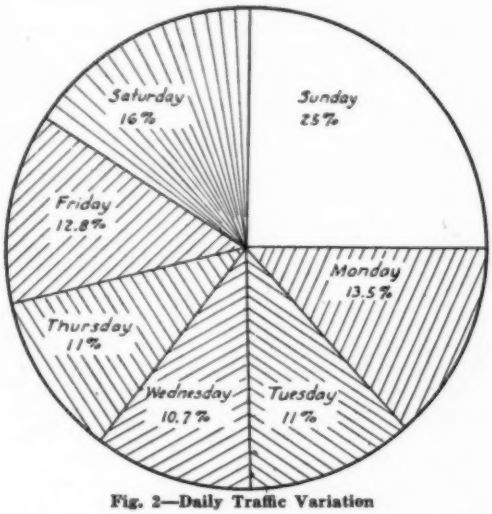


Fig. 2—Daily Traffic Variation

taken as 100 per cent. Then the average traffic for the year would be 10,000 vehicles per week, from which the average daily, monthly or yearly traffic can be computed.

While a traffic estimate for a California highway, based on this graph of traffic on a Connecticut road, probably would be wrong, a single yearly census in California should serve for all the paved roads in the state for several years to come. With that one census covering a year's traffic as a guide, the weekly census would give a pretty accurate indication of the traffic any road was carrying.

And if each state made a yearly census on paved, graveled and earth roads it could count traffic on any type of road for a week and arrive at a reasonably close idea of traffic for the year.

Figure 2 shows how traffic on the Old Lyme bridge was divided among the various days of the week. The chart represents the traffic on all the Sundays, Mondays, etc., for the year in per cent of the total yearly traffic. The Monday percentage for this particular year was probably raised by two holidays, July 4th and Labor Day.

Figure 3 shows the monthly and seasonal variation in traffic. Had the astronomical summer period from June 21st to Sept. 21st been used instead of the calendar months June, July and August, over half the yearly traffic would have been found in that quarter of the year.

Figure 4 shows the relative number of the various types of vehicles using the bridge. Horse-drawn traffic, it will be noted, is scarce, there being only one such vehicle for 250 which are motor driven.

Valuation Engineers Wanted.—The U. S. Civil Service Commission, Washington, D. C., has announced the following open competitive examinations: Valuation engineer, at entrance salary of $3,800; assistant valuation engineer, at entrance salary of $3,000. The examinations are to fill vacancies in the Technical Staff of the Income Tax Unit of the Bureau of Internal Revenue, Treasury Department. After the probational period required by the civil service act and rules advancement in pay without material change in duties may be made to higher rates within the pay range for the grade, up to a maximum of $5,000 a year for valuation engineer, and $3,600 a year for associate valuation engineer.

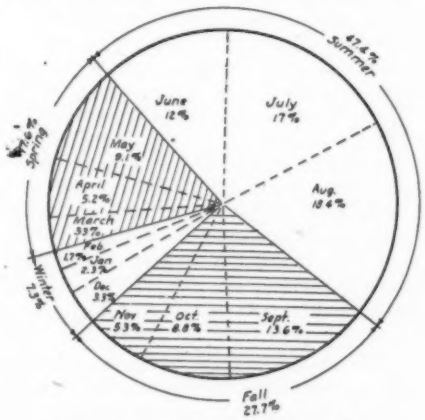


Fig. 3—Seasonal Traffic Variation

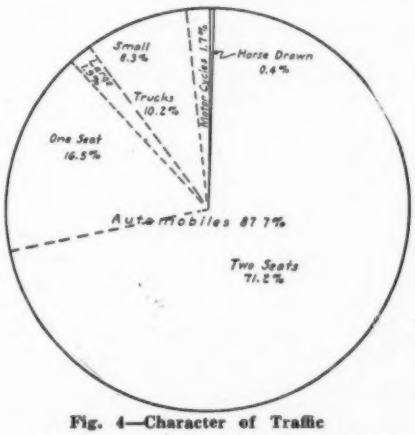


Fig. 4—Character of Traffic

Laboratory Control of Aggregates

Procedure of Michigan State Highway Laboratory Described in Paper Presented Feb. 17 at 12th Annual Conference on Highway Engineering, University of Michigan

By ROGER L. MORRISON

Associate Professor of Highway Engineering at University of Michigan, and Director Michigan State Highway Laboratory

The quantity of aggregates used by the state highway department is much greater than that of any other material, as they form nearly 90 per cent of the concrete bridges and culverts, and the concrete and bituminous pavements, and 100 per cent of the gravel roads. During the year 1925, the department used approximately 24,000 carloads of aggregates in concrete bridges, culverts and pavements, 1,700 carloads in bituminous pavements, and 13,000 carloads in gravel roads, making a total of 38,700 carloads.

With this in mind, it can easily be understood that insuring the quality of these aggregates is a very important matter. This vast amount of material is produced under varying conditions in numerous plants all over the state and it is only by careful inspection that the quality can be kept up to standard.

Reasons for Specifications—So far, the laboratory has been concerned primarily with the control of concrete aggregates, and it will probably be sufficient to discuss them in this paper.

The first step in obtaining proper aggregates is, of course, the drawing of the specifications. As it is one function of the laboratory to assist in preparing specifications, the reasons for some of the provisions will be considered.

The specifications are frequently taken more or less for granted by the less experienced field men, without much attempt to analyse the reasons for the various provisions and as a result it is sometimes difficult to form a sound judgment as to whether certain materials on the border line should be accepted or rejected. In fact, if the young engineer attempts to find a book which will interpret aggregate specifications, he will search in vain and it is the lack of available information on this subject which seems to justify a brief discussion of some points which may be entirely familiar to the majority of engineers.

If the sand is not clean, the cement will not adhere to it properly and the resulting concrete will not be as strong as it should be. Lumps of clay will not make good concrete though a small amount of clay and silt does no particular harm if evenly distributed and not in the form of lumps or a coating on the sand grains, hence it is customary to permit 2 to 3 per cent. In fact, it is practically impossible to eliminate all clay and silt from sand. A small amount of organic matter in the sand may cause a serious failure of the concrete. For instance, shipping a sample of sand in a sugar or oat sack may destroy its tensile strength, as will small amounts of decayed wood or oily shale. Unless the sand is hard and durable the grains will fracture under traffic and break out, leaving the concrete surface pitted. Crusts or hardened material may not break up in the mixer to form mortar.

When it comes to the grading of aggregates, there is enough difference of opinion among experts to cause anyone to hesitate before making any dogmatic statements, but there are certin things which are generally accepted as facts. One is that with given proportions of cement, water and sand, coarse sand will make stronger mortar than fine sand. Hence the specification that not more than 95 per cent shall pass a 10-mesh sieve. On the other hand, it is sand that we want for fine aggregate and not gravel, so we say that at least 95 per cent must pass a ¼-in. screen, while the 20-mesh and minimum 10-mesh requirements are added to give a uniform grading and low void content, thus presumably increasing the strength of the mortar. If the sand does not contain at least 5 per cent of particles passing a 50-mesh sieve, the concrete will not finish easily and this requirement would be raised to 10 per cent if such sand could be generally obtained.

"The proof of the pudding is in the eating" and therefore, we say that when tested in comparison with standard Ottawa sand, which is of uniform size (20 to 30-mesh) mortar made with the sample sand shall be at least as strong as that made with the standard sand. Tensile rather than compressive strength is tested in this case, because the former test is more easily made, the results are more

consistent, and the compressive strength varies approximately as the tensile strength.

Much that has been said regarding fine aggregates applies also to coarse aggregates. Thin or elongated pieces are more easily named than defined and it is doubtful if their exact effect upon concrete is known, but they are apt to break easily and form excessive voids so that they are believed to be harmful. Few aggregates are entirely free from such material, and the percentage which warrants rejection is a matter of opinion.

As nearly all gravel deposits in Michigan contain more or less soft sandstone, keel (clay ironstone), and similar materials, it is practically impossible to eliminate them entirely, and this situation is recognized to the extent of permitting as much as 2 or 3 per cent by weight. The exact effect of this material is not known as yet, but the laboratory is now making a series of tests of concrete specimens containing varying amounts of soft stone. It is believed that excessive amounts of such material decrease the strength and wearing qualities of concrete, at least indirectly by requiring more water to produce a given slump, and the extra water is harmful. Soft stone tends to "float" to the surface as the concrete is placed and it is then liable to be disintegrated by frost and traffic. Pieces of shale in the surface are knocked out by traffic and leave pits. These pits frequently have a small amount of shale left in them which clearly indicates their origin.

Increasing the maximum size of the coarse aggregate increases the strength of the concrete so long as the material can be handled easily in the work. Therefore, a maximum size up to 2½ in. is permitted and at least 25 per cent must be retained on the 1 in. screen. The 13 per cent allowed to pass the ¼-in. screen is merely a tolerance, which would be eliminated if practicable. The use of unscreened aggregates is not permitted because of the difficulty of keeping the proper ratio between the fine and coarse aggregates as furnished and the danger of segregation of sizes in handling.

Specifications Cover Material When Used.—The laboratory places inspectors at aggregate plants when the quantify furnished the state amounts to as much as ten cars a day, but it is sometimes necessary for the engineers to reject aggregates on the job which have been passed by the plant inspectors. This practice has been frequently referred to by contractors and aggregate producers as "double inspection" and has been strenuously objected to by them. Such objections to so-called "double inspection" are, however, based upon a misunderstanding of the situation.

In the first place, the specifications form a part of the agreement with the contractor and cover the materials at the time they are placed in the mixer. It would be entirely logical under the contract to have all inspection performed on the job, even right at the mixer skip, all unsatisfactory material being rejected at the last moment only. This, however, would involve a great expense in freight and handling charges on rejected material and frequent annoying delays to the work. To reduce such expense and delays to a minimum, the State places the inspectors at the plants to stop unsatisfactory aggregates at the source. In other words, the inspection is essentially at the job, but a man is put at the plant to keep poor material off the job so far as he is able to do so.

Difficulties of Plant Inspection.—As a matter of fact, there is very little material which has to be rejected on the job after it passes the plant inspector, but it is extremely doubtful if plant inspection of aggregates can ever be made 100 per cent perfect. In the case of such materials as cement and steeel, samples can be taken in a specified manner from each car and every sample can be tested, so that when a car is once approved there is no reason for subsequent rejection, except possible deterioration from some cause after shipment.

Unfortunately, however, aggregates are not susceptible to such exact plant inspection methods. As an extreme case, there is one plant which has a capacity of about 200 cars daily. This would be an average of a car every 7 minutes during a 24 hour day, if shipments were at a uniform rate, and with a much smaller daily output, the rate of loading may be as fast, or even considerably faster, for a few hours a day. As it takes at least 10 minutes to sample a car properly, and nearly 2 hours to make a complete test of a sample, it is absurd under such conditions to say that an inspector's card on a car should be considered as a guarantee of quality and that all further inspection should be eliminated. What actually happens is that one inspector watches the car as it is filled and if it looks all right he signals another inspector who tacks on the card. Five minutes later the car may be half a mile down the track and 30 minutes later it may be on the main line headed for the job. In some other cases, aggregates are loaded and shipped at night which of course makes plant inspection still more difficult.

The Production of Aggregates.—Having shown what plant inspection cannot accomplish, the next thing to do is to show what it can, and does, accomplish. To make this clear it may be desirable to describe briefly the construction and operation of such plants

for the benefit of those who may not be familiar with them.

Most of the aggregates used in Michigan consist of sand and gravel and the plants for their production consist primarily of gravel pits, screens, conveyors and bins. A detailed description of the various types of plants is beyond the scope of this paper, so that only those most commonly used will be considered.

The gravel is usually loaded from the bank and hauled to the screening plant in cars. It is dumped through a large screen or "grizzly" into a hopper from which it is carried to the top of the plant on a conveyor belt. It then passes through a series of revolving screens fitted with water pipes and is washed while it is being screened. Stones too large to pass the specifications are crushed and then passed through the screens; after being screened and washed the gravel and sand are dropped into bins, each bin containing aggregate of a certain size, or sometimes it is dropped into stock piles over a loading tunnel. From the bins or stock piles the materials go to loading bins where the different sizes are combined in the proper proportions, or other methods may be used for getting the proper combination. The loading of cars for shipment may be done by means of loading belts or through gravity chutes.

Starting Plant Inspection.—When the laboratory is notified that a plant is shipping as much as 10 cars daily to a state highway project, an inspector is sent to the plant. Before a new man is sent out as a plant inspector, he is drilled for at least a week in the Ann Arbor Laboratory in the testing of aggregates, and if possible is taken to nearby plants to observe their operation, or he may serve for a short time as an assistant inspector under a more experienced man.

When he receives an assignment, the new man, together with his equipment, is taken to the plant by the chief inspector.

Upon arrival at the plant the equipment is first checked and set up by the new man, and he is instructed in its use under the handicaps of location outside the laboratory. The standard equipment consists of the necessary screens and sieves, 2,000 gram capacity scales, 200 c.c. glass graduates, a supply of sodium hydroxide and bottles for organic matter tests, a trowel, counter brush, drying pans, large spoons, sample sacks and stationery. A small oil stove is required if there are no facilities at the plant for drying aggregates.

After the equipment has been arranged, the pit is visited and the chief inspector points out possible sources of trouble, such as excessive overburden not removed, clay pockets in the bank, parts of the bank containing an excess of fine material, old stumps, possible oily shale ledges, or other sources of organic matter. This study of the pit puts the inspector on guard against the particular difficulties which may arise from that quarter.

From the pit the inspector is taken to the top of the screening plant. As a rule he can get a bird's eye view from there of the entire layout of pits, tracks, waste piles, etc., which gives him a clear idea of the general system of operation.

Next the material is followed down through the plant and the screening and washing method are studied. Such items as possible overloading of screens, insufficient water supply, etc., are noted. Special attention is paid to the arrangements for combining sizes and loading cars. The attention of the new inspector is called particularly to points where segregation may occur.

After this examination of the plant a conference is held with the plant superintendent and suggestions are made as to possible methods of eliminating sources of trouble. For instance, arrangements may be made for additional stripping work to reduce the amount of clay going through the plant, the steam shovel may be moved to another part of the pit, the rate of feeding the screens may be reduced, more water may be used in washing, or washing may be done at additional points, arrangements for combining sizes may be improved, baffle plates or other devices may be installed for reducing segregation in loading cars, and one or more men may be put to hand-picking soft stone from conveyor belts. By such methods the quality of the product can often be greatly improved with very small expense to the producer.

The new inspector is then ready to begin work and he is first taught how to sample cars. This is one of the most difficult operations in the whole field of highway materials inspection, and a carelessly taken sample may not come anywhere near to representing the actual average contents of the car. Incidentally, it seems rather like wasted energy to argue over fine-haired differences in screen sizes until the general methods of sampling and handling materials can be so rigidly specified that reasonably consistent results can be obtained on different samples taken from a single car of gravel at different times.

Method of Sampling Cars.—The method used by our laboratory in sampling cars is to dig "shoulders" on about six or seven of the "waves" formed by the movement of the car in loading. About three of these shoulders are usually dug in the center of the waves and the other four about half way between the center line and the side of the car, half of them being located on each side of the center line. Samples are then taken by digging into each

shoulder, and these samples are placed upon a piece of canvas. After thorough mixing, the combined sample is quartered, if necessary, to get a single sample of the proper size. Some additional digging should be done to detect the possible presence of sand cores at some distance below the surface.

Last year Mr. W. E. De Young made a detailed study of sampling methods and the results of his investigation may be found in the Proceedings of the 1925 Michigan Conference on Highway Engineering.

After learning how to sample the cars properly, the new inspector is given additional instruction in making tests under plant conditions, in making reports, etc. Usually the chief inspector remains at the plant for a day or two until everything is running smoothly, and then he makes frequent visits to it during the construction season.

Routine Inspection.—The routine inspection consists of doing from day to day more or less of the work which has been outlined above, the exact routine depending upon varying conditions at the different plants. As a result of his tests, the inspector soon becomes sufficiently familiar with the aggregates being produced so that he can make a fairly accurate estimate of the grading by watching the loading of the cars. Whenever it is possible to do so, he samples about a third of the cars, and then tests the samples at such times as the plant is not loading cars for State work. It is evident that the majority of the cars must be passed or rejected on the basis of visual inspection only. This is not complete inspection, so that, as previously stated, additional examination, and possible rejection, at the job does not constitute double inspection.

Once each week the inspector tests a sample each of fine and coarse aggregate and then sends the samples in to the Laboratory, together with the results of his tests. Check tests are made there and if there is any appreciable variation in results the inspector's testing methods are checked up.

One of the greatest difficulties with which the inspector has to contend is the formation of sand cores due to segregation in loading. The fine material often drops immediately to the bottom of the car and remains in place while the coarse material rolls to the side. As these sand cores are at the bottom, it is difficult to detect them after the car is loaded. Every effort is made to watch for their formation and to eliminate them by correcting improper loading methods, and the installation of anti-segregation devices, but in spite of all efforts they will sometimes "get by" the plant inspector without being detected.

The assistance of the field engineers is earnestly solicited by the laboratory in completing the inspection of aggregates. Any material obviously unsatisfactory should be rejected without hesitation, a sample and report, including car number and date, being sent to the laboratory for record and so that the situation can be brought to the attention of the plant inspector. Questionable shipments should likewise be sampled and reported, and, if possible, held until the laboratory can make an investigation.

A word should be said in regard to the excellent cooperation which the laboratory has received from the producers. Last year several representatives of the highway department attended the annual meeting of the Michigan Gravel Producers Association, explained some of the things we were trying to do, and requested suggestions from the producers. The association appointed a committee to meet with a department committee at Ann Arbor, and many points were discussed at the committee meeting. This resulted in a better understanding by each side of the aims and problems of the other side, and during the season of 1925 there was not a single controversy which was not settled amicably, and to the satisfaction of both parties.

Chair of Highway Engineering for London University

Steps are being taken to raise an endowment of $150,000 for founding a chair of highway engineering at London University. The course, which is to be post-graduate, is intended to cover a period of three years, at the end of which time those students who pass the final examination are to receive the Degree of B.S., Highway Engineering. The draft syllabus has been drawn up and comprises mathematics (including trigonometry, geometry of space, elements of differential calculus, etc.), also applied mechanics, engineering drawing and design, physics and chemistry, quarry plant (development and practice), bridge construction, graphics, geology and surveying, coast protection works, steel masonry, ferro-concrete, advanced engineering, building construction and theory of structures, municipal engineering, including water supply and waterworks construction, sewage, and sewerage disposal, refuse disposal, roads, street paving, tramways, street subways, highway law, local government practice in relation to highways, inspection of works in progress, office routine, including preparation and keeping of costs accounts, etc., etc.

New England Road Show

An Account of the Open Air Exhibition Road Machinery and Material Held May 13 and 14 at Boston, Mass.

Road machinery of all types was shown in operation at the second annual open air show of the Massachusetts Highway Association at the Charles River Parkway, Boston, May 13 and 14. Engineers and officials from all parts of New England were in attendance and with ideal weather conditions the affair was a great success.

A noticeable feature of the show was the large number of smaller units and lighter types of machinery and this was logically explained by the fact that New England is already covered by so complete a net work of improved highways that construction jobs there seldom exceed two or three miles in length and hence the market for large equipment is very limited. But just as noticeable was the fact that even for the lightest tasks wherever possible gasoline engine driven equipment was employed.

Among the new devices developed since the Chicago Road Show were a bucket type loader shown by the New England Road Machinery Co. of South Boston; a machine for planing off ice ruts or humps just perfected by the Gifford-Wood Co. of Hudson, N. Y.; a new hoist provided with winch head or rope drum for attaching to portable air compressors just being put on the market by the Ingersoll-Rand Co., New York; a new Barber-Greene loader and a new trench back filler made by the Miami Trailer-Scraper Co. of Troy, Ohio, and operated with a Fordson tractor.

The exhibition place was ideally located on the Cambridge side of the Charles River. The display spaces were arranged in a huge oval the center of which formed the arena for the earth handling machinery to show off its tricks of operation. No sooner had one set of machines torn the soil up into a veritable upheaval when a battery of tractors would pull graders and scrapers over it and prepare the place for another onslaught of the shovels, loaders, scarifiers and performing caterpillar and crawler tanks.

Many of the elite among the highway officials viewing the spectacle had an excellent point of vantage from the space of the Granite Paving Block Manufacturers' Association where the genial Secretary-Host "Joe" Tobin had placed brilliant colored sun shades giving the scene a touch in keeping with its name, "Gaffey's Beach."

The most spectacular feature of the show was the performance of the tractors. John Q. Cragin, manager of the tractor division of the Cambridge Branch of the Ford Motor Co. had marshalled about him an imposing array of contractors' equipment wherein the Fordson supplies the power. There was a complete line of scrapers and backfillers made by the Miami Trailer-Scraper Co. of Troy, Ohio, demonstrated by I. I. Goodrich, General Sales Manager. W. F. Dunn of the Wehr Co., Milwaukee, showed the Fordson equipped power grader and scarifier. W. V. Tomlinson of the Anthony Co., Inc., Streator, Ill., demonstrated the various dump bodies, hand hoist dumps and Fordson power shovel. The Full Crawler Co. of Milwaukee was represented by J. L. Hawes who saw to it that most of the Fordsons shown were equipped with Full Crawlers. N. Bart Dancy of the Oklahoma Engineering & Foundry Co. of Muskogee, Okla., drove a Fordson equipped with the White Tractor Hoist.

The New England Structural Co. who had an individual booth showing sidewalk specialties also came in for part of the Fordson show by way of a special sidewalk snow plow attached to a narrow tread tractor. R. F. Symonds was in charge of the Nesco activities. The advantages of Ruckstell Axles were also shown and the Union Iron Works, Inc., of Bangor, Me., had a fine display of Sargent snow plows equipped to Fordson Full Crawlers.

The Meade-Morrison Mfg. Co. of East Boston was very much in evidence with three of the latest type 5-ton crawler type tractors. Two of these were shown with winter equipment including cab and lights. A half yard Meade-Morrison gasoline shovel was also shown. C. F. Reuter who was in charge of this exhibit with the assistance of B. A. Cooper had much to do with the successful operation of the whole show as a member of the Executive Committee.

The Eastern Tractors Co. of Cambridge, Mass., had a battery of ten caterpillars ranging in size from 2 to 10 tons capacity. Major A. L. Crafts, sales manager, was in charge. These tractors were used with Stockland graders, Baker-Maney scrapers, Sargent plows and La Plant-Choate, Cedar Rapids dump wagons and trailers. A feature of this exhibit was "Big Red" snow fence, made of wood lath spaced by galvanized wire of a special heat-treated process. The fencing is made by the Illinois Wire & Manufacturing Co. of Joliet, Ill.

One of the large exhibits attracting a good deal of attention was that of the Dyar Sales Machinery Co. of Cambridge, Mass. It was presided over by B. J. Surrett, general manager of the company. One of the principle lines shown here was the "Boss" mixers of the American Cement Machine Co., Inc., of Keokuk, Ia., and their display was kept at a high pitch of interest by H. R. Hayden, sales mana-

ger of the American Company, who was very much on the job. It was at this exhibit that the new Ice Planer for smoothing out ruts was shown by the Gifford-Wood Co. of Hudson, N. Y.

Among the other Dyar exhibits were Adams graders, Wilcox Bros., Inc., Foote pavers, Chas. Hvass & Co., Inc., brooms, tar kettles, etc., A. B. C. highway line markers, Burch Plow Works spreaders and car unloaders, Oliver Ames shovels, Dietz lanterns, Watson wagons and trailers and Humphreys Mfg. Co., of Mansfield, Ohio, pumps. Among the latter equipment the new diaphragm pump mounted on a steel frame, pneumatic tired trailer occasioned considerable favorable comment.

W. S. Railsback, president of the New England Road Machinery Co. of South Boston was kept very busy demonstrating their new self propelling and self feeding bucket type wagon loader. It has a capacity of 200 yards a day and is operated by a Le Roi four cylinder gasoline engine. Of course the well known "New England" steel rock crusher was there and a portable crushing and screening plant was shown as well as drag line scrapers, portable belt conveyors, tar kettels, road drags, snow plows and hardpan rooter plows.

The Hedge & Matthies Co. of Boston with F. W. Matties and J. O. Jordan, Jr., in charge had another of the very busy sections of the show. Conspicuous was the new Model 42 bucket loader of the Barber-Greene Co., of Aurora, Ill. The type V Barber-Greene conveyor was also shown in operation. Other equipment included the Mixermobile, an 8x6 Ingersoll-Rand Compressor, a 7 S Marsh Capron Power Loader trailer mixer, a 3½ S Marsh Capron Trailer Mixer, a 3½ C. T. Jaeger mixer, a C. H. & E. Centrifugal pump, a C. H. & E. "Double Mud Hen," an Aeroil Asphalt Kettle, Wood's "Moly" shovels, Jackson wheelbarrows and the "Porta" tractor hoist.

Because of the large amount of nationally prominent equipment displayed, the booths of the Aberthaw Company of Boston were the center of general interest. C. K. Roulston was in charge. The Haiss "Traxion Chassis" on the Fordson vied with the other tractors for attention and the well known Haiss bucket loader performed busily and with great success in the center of the field. Leach-Oshkosh mixers and saw rigs were shown in operation. Four types of "Humdinger" contractors' pumps made by the Ralph B. Carter Co. of New York were shown. Air compressors of several types for road builders' use made by Schramm, Inc., of West Chester, Pennsylvania, were shown and the S. Flory Manufacturing Co. of Bangor, Pennsylvania, had their gasoline hoists in operation. In the background of this live, energized exhibition of modern performance was the display of the Continental Motors Corporation of Detroit, Michigan.

The Acme Road Machinery Co., Inc., of Frankfort, N. Y., through J. M. Berry, manager of their New England branch at Cambridge, Mass., presented a very interesting exhibit. The "Pony" Gas Roller was one of the main objects and the "Tri-Utility" road builder showed how this machine is employed for grading and scarifying as well. Heavier types of Acme rollers and scarifiers testified to the wide range of the companies' product as did crushers and screens. A novelty was their "Hotstuf" oil burning asphalt heater because of its spectacular operation and several features of interest.

Clark Wilcox, Inc., of Boston had an interesting display with F. P. Wilcox in charge. One of the latest type P. & H. half yard shovels made by the Harnischfeger Corporation of Milwaukee, Wis., certainly did some crowding out in the dirt lot. Several Ransome mixers were shown by experts of the Ransome Concrete Machinery Co. of Dunellen, N. J. A 5½ by 5 Ingersoll-Rand portable compressor and Barnes diaphragm and duplex plunger pumps were there. Models showing the use of "Metaform" road building forms made by the Metal Forms Corporation, Milwaukee, Wisconsin, were displayed.

A. S. McLellan was in charge of the exhibit of the Ingersoll-Rand Co. of New York. Considerable interest was shown in the new "Utility" a hoist for use with portable air compressors. It was shown mounted on one of their 5½ in. by 5 in. machines which was in operation. It was used for hoisting and pulling; for backfilling in trench work and showed how it could be utilized for shifting of the compressor itself. A complete line of pneumatic tools were also on exhibition.

The outstanding features of the exhibit of the C. R. Dodge Co. of Boston were "Dandie" mixers of the Koehring Co., Milwaukee, Wisconsin and "Patrol" graders of the Russell Grader Manufacturing Company of Minneapolis, Minn.

Nelson B. Conant, president of the Conant Machine Co. of Concord Junction, Mass., was in personal charge of a very interesting exhibit of mechanical loaders..

Through its New England branch of Watertown, Mass., the Good Roads Machinery Co. of Kennett Square, Pennsylvania, had a "Monarch Cub" gasoline road roller in operation as well as a full line of graders, scrapers and Champion snow plows.

The Four Wheel Drive Auto Co., Clintonville, Wis., was represented by its representatives, C. J. Cassere and John W. Emmons of

Somerville, Mass., in showing two three ton trucks and one Menominee one ton "Hurryton."

The Sullivan Machinery Co., Chicago, Ill., was represented by George A. Richey, Boston manager, and George A. Rowen in showing a portable air compressor and line of pneumatic tools.

The International Harvester Co., Chicago, Ill., had L. E. Smith, New England manager of Somerville, Mass., in charge and gave ample evidence of its presence in the road building and tractor field. An industrial tractor with Mandt crawlers performed energetically as did one with the one man grader of The Hadfield-Penfield Steel Co. of Bucyrus, O. A model 68 dump truck was also shown in operation.

H. L. Alley was in charge of the Warren's Utility Asphalt plant and Pacific type sand dryer shown by Warren Brothers Co., Boston, Mass.

The Solvay Process Co., New York, represented by C. M. Adams, Jr., and J. A. Phelan had an interesting exhibit showing benefits of surface treatment of roads.

The Evernu Century Sign Co., Boston, displayed flashing beacons and electric warning signs and signals by the Horni Signal Mfg. Co. of New York. Stanley S. Butler was in charge.

Stanley Field of Walter W. Field & Son, Inc., of Cambridge, Mass., showed "Handy-Andy," the power unit for contractors made by the John Waldron Corporation of New Brunswick, N. J.; the gasoline hoist of the Lambert Hoisting Engine Co. of Newark, N. J., and the Metalweld-Worthington portable air compressor built by the Metalweld Company of Philadelphia.

L. F. Bryant, Boston manager of the Buffalo Springfield Roller Co. of Springfield, O., demonstrated a 5-ton 3-speed 3-wheel gasoline road roller.

An Elgin sweeper was shown by the Elgin Sales Corp., Watertown, Mass., with G. A. Pratt, manager, in charge.

W. C. Brockway, Charlestown, New England manager of the Philip Carey Company, Lockland, Cincinnati, Ohio, makers of Carey Elastite Expansion Joint treated those who hungered for information to the marvels of "The Sandwich Joint." Especially interesting was his demonstration of the Carey rail fitter and new method for paving grade crossings.

The American Castings Co., Birmingham, Ala., through M. S. Kahurl, Boston manager, displayed spiral corrugated cast iron culvert pipe.

The Berger Mfg. Co., Canton, Ohio, R. C. Walker and A. R. Larrabee, Boston representatives, showed "Armco" Culverts and Cyclone road guard fencing.

The Puritan Iron Works, Boston, had an array of catch basin castings.

F. T. Ray, manager of the Road Oil Department of the Boston branch of the Standard Oil Co. of New York, was in charge of their exhibit.

The White Co., Cleveland, through their Boston branch demonstrated the new Model 52 Contractors Dumping Truck which is gaining great favor among road builders.

Pierce Arrow trucks and snow plows and Sterling trucks were shown by their Boston branches. The Mack dump truck was also shown. The Universal Hoist & Body Co., Boston, displayed dump hoists and truck bodies.

7-S Mixers on Crosswise Trucks

Announcement is made by the T. L. Smith Co. of Milwaukee, Wis., that its non-tilting type of 7-S Mixers can now be furnished on crosswise trucks for end discharge like a paver. This arrangement is of advantage where the

Smith 7-S Non-Tilting Mixer Equipped With Crosswise Trucks for End-Discharge as on a Paver

job is strung out as in conduit, sewer, curb and gutter, and grouting work, and in sidewalk and alley paving. Mixers with this equipment are now available at the factory. The standard wheels and axles are removed intact and installed on the crosswise frame. The standard frame is arranged to be bolted to the new unit. A hauling stub, telescoping under the skip, is used in place of the standard. The stationary spout allows ready placing of the concrete directly into the forms, but an 8-ft. distributing spout with a swing of a half circle can be furnished as an extra. The distributing spout with the two discharge points allows accurate placing of the concrete.

Model Traffic Ordinance in Illinois.—Twenty-eight cities of Illinois have adopted the model traffic ordinance formulated by the Illinois Municipal League.

State Highway Maintenance in North Dakota

The Methods to Be Followed in 1926 by the State Highway Commission Outlined in North Dakota Highway Bulletin

By T. G. PLOMASEN
Maintenance Engineer, North Dakota Highway Department

By Chap. 167, Laws 1925, the last legislature imposed the duty of maintaining the improved portions of the state highway system on the state highway commission. Prior thereto, the state highway department has exercised merely a general supervision thereover, the actual responsibility for the work resting on the various boards of county commissioners who employed patrolmen to care for a given section of the state highway system within their respective counties. While these men were often selected with the advice of the highway dpartment, their rate of compensation was fixed by the local board which resulted in considerable discrepancies in the pay these men received in the different counties though the work may have been of the same nature and extent. While the new law went into effect on July 1st of last year, that is, in the middle of the maintenance year, it was felt that it was impractical to reorganize the entire maintenanec policy or organization at that time as it might result in disorganization and a general let-down in the work. Therefore, the work done last fall was continued under the old policy and methods. But, beginning with this year, the full and entire responsibility rests on the state highway department and the maintenance section thereof in particular.

Organization of Maintenance Department.—After the highway has been improved by the construction department of the state highway commission, it is turned over to the maintenance department and also subsequent action thereon comes under its jurisdiction unless that particular portion is again turned back to the construction forces for betterment such as gravel surfacing or paving. While there are 7,434 miles in the entire state highway system, it is only the improved part that is maintained by the state highway commission at the beginning of the year the maintenance department had under its jurisdiction 2,350 miles of completed federal aid highways though it anticipates an additional 135 miles will be turned over to it within the next 60 days. At least, preparations have been made for the maintenance of this additional mileage. The mere fact that an unimproved section of the highway system has been marked with the well known Indian head marker does not mean that the section will be maintained or patrolled.

The maintenance department performs a dual function—it not only maintains the highway but also marks it so that the public may know the route, and in the handling of this work the same general employes where possible will do all the work as marking department as a separate and distinct unit of the state highway department has been abolished. Subject to the state highway commission and the chief engineer and secretary thereof, the man in charge of the maintenance department is the maintenance engineer. Next, in point of responsibility, are the five division engineers, each in charge of one of the districts as shown by the name of his headquarters as the Bismarck, the Minot, the Valley City, the Devils Lake and the Dickinson divisions. They will exercise a general supervision and control over the field work of maintenance and road marking. Under them and in immediate charge of the work are the maintenance superintendents, of which there is one in the Bismarck division, one and an assistant superintendent in each of the Minot and Devils Lake divisions, and two superintendents in the Valley City division. The improved mileage of the state highway system in the Dickinson division is so small comparatively that the assistant division engineer can also act as maintenance superintendent. The desirability of this plan of supervision is clear from the number of improved miles of state highway in each division, which is as follows: Valley City, 878 miles; Minot, 490 miles; Devils Lake, 592 miles; Bismarck, 403 miles, and Dickinson, 122 miles.

As already noted, there are at this writing about 2,485 miles to be maintained. These have been divided into patrol sections varying in length from six to eleven miles, of which 259 are horse patrol sections, six tractor patrol

sections, and seven truck patrol sections, and 272 patrolmen have been employed to do the actual work of keeping the system in good condition for travel.

The Horse Patrol Section.—The horse patrol section, of which there are 259 in number, varies in length from 6 to 11 miles and is in charge of a patrolman who is responsible for the upkeep of his definite section of the state highway system. He is under contract to do this work from the date thereof until the close of the year. Where possible, a patrolman has been secured who lives near the center of a patrol section so as to enable him to work advantageously. The pay of the patrolman is uniform throughout the entire state and he is to receive 60 ct. per hour when working with team, wagon, fresno and hand tools; 40 ct. per hour when without team; 80 ct. per hour when working with team and mower. He is, also, allowed 10 ct. per hour for each extra horse when the same is necessary. Extra men can not be used except when authorized by the commission and receive 35 ct. per hour. During the 7 months period beginning April 1st to Oct. 31st, every patrolman must devote every hour of the day, up to 10 hours, and every day to the upkeep of his section, weather permitting. He is even expected to work on Sundays and legal holidays when conditions render this necessary, but at such times is not allowed to do any regular routine maintence work. During the winter months, that is, from Nov. 1st to March 31st, patrolmen are required to devote a sufficient amount of their time to patrol work to keep their section in good condition.

Each patrolman is required to furnish at his own expense: Wagon, mower, two horses, fresno-scraper, all hand tools necessary, such as crow bar, pick, shovel, rake, hoe, scythe, etc. The team must not weigh less than 1,400 lb. each. The highway commission furnishes him with a blade grader.

Six Tractor or Engine Patrol Sections.—There are six tractor or engine patrol sections and these vary in length from 13 to 24 miles. The power to be used in these patrol units this year are five Fordsons and one 10-20 McCormick-Deering engine. Three of these power graders are of the push type, the engine and grader being integral. On these units, the engine is set in the grader frame at the rear of the grader and the grader is pushed forward by the engine. On the other three power graders the front wheels are removed and the front of the grader is attached and supported directly on the Fordson. The entire unit is operated from the grader seat. The engine of two of these patrol graders is owned by the patrolman and he is paid an hourly rental for the use thereof. The highway commission will furnish a patrolman with the graders to attach to the engines. In taking hold of any new proposition such as state-wide maintenance, by the state highway department, there must naturally be some experimenting, and hence if this combination proves successful, it will save the state highway commission the responsibility and expense of the upkeep and ownership of the engines used in power patrol work. The state highway commission will pay the patrolman for the number of hours the tractor actually works on the road. The patrolman is to furnish the gas and oil, and take care of all repairs and depreciation. He will not be paid for time spent repairing his tractor. Under this plan, it is quite probable that the machine will operate more hours than if the state highway commission owned the tractor and made the repairs because it will be strictly up to the patrolman to have his machine in good working condition in order to draw his pay.

It has been found that there is a general disregard on the part of employes of the responsibility of caring for machinery of the employer and this especially is true where such machinery is the property of the state or some sub-division thereof. If the equipment belongs to the individual as his personal property he is more likely to conserve it carefully. For that reason, it has been concluded to let the patrolman furnish the power, and care for the operating expense such as gasoline, oil, grease and repairs and to pay him on hourly basis for the time actually devoted to patrol work.

The Truck Sections.—There are seven truck patrol sections where heavy duty trucks will haul heavy drags. Six of these will operate on earth graded highways alone, and the seventh truck will be used to operate a Havelock road maintainer on gravel. These patrol sections range from 12 to 18 miles in length and most of them located in the northwest section of the state, where some difficulty has been experienced in procuring satisfactory patrolmen owing to the scattered condition of the population and other highway conditions.

Reshaping the Highways.—In addition to the general method of patroling the road, it will be the policy of the maintenance department occasionally to supplement this work with heavy equipment to do such work as may be beyond the capacity of the lighter equipment to perform. At the present time, the state highway commisison has practically no heavy equipment but contemplates the pur-

chase thereof later as the actual necessity therefor is clearly demonstrated.

It has been the experience of the state highway department as well as those of other states that periodically the highways must be re-shaped in order to keep them in proper condition. This class of work can only be done with units possessing an abundance of power and weight to penetrate the road crust that is formed by the traffic. Very little equipment owned by the state highway commission is of this type and an endeavor will be made to contract for this class of work on the basis of the lineal miles traveled by the reconstruction unit. Under the plan contemplated, the contractor must furnish a tractor of not less than 40 hp. rating at the drawbar, a grader with independent scarifying attachment and such other blade attachments as may be necessary. The contractor is also to furnish the tractor operator and to pay all operating expenses. On the other hand, the state highway commission will furnish a grader operator who will represent the maintenance forces and determine the extent of the work necessary. The equipment to be furnished by the contractor must be capable of doing the same kind of work that is usually done by reconstruction units of this type and must be kept in workable condition at all times. If contractors of sufficient experience and responsibility can be found who will take on this line of work, the state highway commission will have a basis for determining whether it is advisable for the commission to own its own reconstruction units or to have such work done under contract as outlined.

Co-ordinating Highway Construction

Editorial in Concrete High Magazine.

An ever increasing tendency to plan and build public works co-operatively is evident. Neighboring communities have found that such a procedure effects economies and the completed structures serve their users more efficiently.

Especially is this true in highway construction. Only a very small percentage of traffic is of a strictly local character. City and county, even state boundaries, mean nothing to the motorist these days. He follows the route that provides him with the best traffic surface regardless of the political boundaries he crosses.

Almost every metropolitan district now has some organization for co-operative planning. In some localities this takes the form of a regional planning association as in Chicago, Los Angeles and other metropolitan regions. These organizations plan all development with regard for the region as a whole. Usually the matter of highway improvement is one of the most urgent of the problems that need solution.

Regional planning such as this is an entirely different matter than city planning because it involves planning for a great number of political units. States, counties, township and municipalities within the region are parties to the development.

Because so many political units are interested, successful regional planning is first of all real co-operation. Experience has shown that the most effective course of action to get concrete results from regional planning is to bring the authorities from each jurisdiction together and get them to agree first on a comprehensive plan and then on methods of undertaking the work proposed. Then each political unit bends its efforts toward completing that part of the plan which falls under its jurisdiction.

Usually there are a great many plans and reports already available and surveys of most of the political units in the region have been made. All these data can be collected and assembled into regional maps from which the needs of the entire region can be studied.

Regional planning on a large scale is now under way in about a dozen communities. Through this work is of comparatively recent origin, definite beneficial results are already noticeable. When the matter of planning public improvements is brought before the interested communities as a truly co-operative effort, it generally meets with ready acceptance. Probably because the larger cities felt the need of community planning more strongly, regional planning is still confined almost exclusively to the larger metropolitan areas. But the less densely populated areas also can benefit by it. It is just as important to plan public improvements co-operatively, especially in highway development, in the smaller communities.

New Officers of Long Beach Chapter A. A. E.—The new officers of the Long Beach Chapter of the American Association of Engineers who were installed April 6, 1926, for the ensuing year are as follows: President, Ward Spencer Smith, M. E.; 1st vice president, Stanley Bone, gas engineer; 2nd vice president, R. R. Shoemaker, C. E.; secretary, Fred S. Porter, mining engineer; treasurer, F. B. Wilder, mining engineer; 3-year director, E. H. Ogier, petroleum engineer; 2-year director, F. H. Gentry, structural engineer; 1-year director, G. A. Christensen, C. E.

The Roughometer and Its Uses

Device for Measuring Roughness of Pavements Described in Paper Presented Feb. 16 at 12th Annual Conference on Highway Engineering, University of Michigan

By J. T. VOSHELL
District Engineer, U. S. Bureau of Public Roads

In 1913 while inspecting the Chevy Chase experimental road I observed there was considerable relative movement between the axle and body of a passing automobile and it occurred to me then that a device measuring this movement would indicate the relative roughness of a road. About a year ago such a device was designed and constructed by the Division of Tests in the Bureau of Public Roads. The designers named it a "Relative Roughness Determinator" but, for brevity I shall refer to it simply as a "Roughometer."

Description of Roughometer.—The device consists essentially of a rack and pinion, the rack being fastened to the front axle and the pinion to the frame of an automobile. The pinion is equipped with a ball bearing clutch so that it moves on its axle freely in one direction but carries its axle with it when moving in the opposite direction. The result is that when the rack is moved backward and forward the axle of the pinion rotates in one direction only. This rotation of the axle is transmitted to the dash of the automobile by an ordinary speedometer cable and through a bevel gear to a Veeder counter. The various parts of the device are so proportioned that a 1-in. movement of the rack registers one unit on the counter. A lever on the dash permits the driver to engage or disengage the pinion from the rack at will so that records may be taken when desired and unnecessary wear of the apparatus prevented when the automobile is being driven and no record is wanted.

From the description it is evident that the automobile itself is an important part of the apparatus and the results secured will be different for each automobile and will vary as the speed varies. The kinds of tires used and degree of inflation of the tires will influence the results. The temperature of the springs and whether or not they are well oiled and the load in the car may have a slight influence.

The roughometer which we have in this district is mounted in a 1917 model Cadillac automobile equipped with five inch cord tires and all of our records have been secured driving at 30 miles per hour with a tire pressure of 60 pounds, the springs well lubricated, and two passengers in the front seat of the car. The speed of 30 miles per hour was selected because we found by experiment that it is about the average speed maintained by automobilists and the one most convenient for us to maintain uniformly over relatively long sections of pavement. At 25 miles per hour we found ourselves obstructing traffic and at 35 miles per hour we found traffic obstructing us very frequently. The tire pressure of 60 lbs. was selected simply because it is a pressure at which the car rides fairly comfortably and at the same time high enough to prevent the tires from being injured.

How the Readings Check.—We are frequently asked "Will the readings check when taken over the same section of pavement?" Following are some readings taken over the same section of pavement one and one-half miles in length at varying speeds.

Three Round Trips at 25 Miles Per Hour

Southbound	Northbound
196	173
199	168
195	170
Average—197	170

Five Round Trips at 30 Miles Per Hour

Southbound	Northbound
225	206
224	203
227	201
230	202
225	203
Average—226	203

Three Round Trips at 35 Miles Per Hour

Southbound	Northbound
242	221
242	224
246	224
Average—243	223

From these data it appears that readings taken under similar conditions check each other remarkably well.

Determining Relative Roughness.—The relative roughness of a pavement is designated by an abstract number which represents the total accumulated compression of the front spring of the automobile in inches per mile. It is the reading shown on the counter at the end of a mile if the counter was set at zero at the

beginning of the mile. This abstract number may be referred to as the "roughness factor" of a pavement. Some idea of what a roughness factor of 100, 200 or 300 means may be gained from the following observations, based on an automobile driven at a rate of 30 to 40 miles per hour:

Roughness factor—

Less than 80—no perceptible vibration

80 to 100—A slight vibration

110 to 150—Very noticeable vibration and slight lurching

150 to 200—Disagreeable vibration and some lurching

200 to 300—Disagreeable lurching and somewhat dangerous for light cars at high speeds.

Last summer the roughness factors were secured for 1277 miles of pavement in Illinois, Indiana and Michigan and from this experience we believe the roughometer as described above does give a true index of the relative roughness of pavements. We are convinced that smooth pavements are desirable and that relatively smooth pavements can be built without appreciably increasing their cost. Roughometer records, which may be secured quickly and at a small cost, we believe, will be valuable to highway officials—particularly supervisory officials who cannot inspect each and every section of pavement—as a basis for rating contractors, superintendents on force account work, engineers, inspectors and all others directly responsible for the quality of the pavement. They will be found valuable even by the highway official who can and does visit all projects during construction, for they will furnish him definite data rather than opinions on which to base conclusions.

Discussion of Data.—A brief discussion of some of the data secured last summer, particularly in Michigan, may be of interest. Forty eight sections of concrete pavement, comprising 412 miles, and five sections of bituminous topped pavement, comprising 59 miles, were tested. The average roughness factor of the concrete and bituminous topped pavement are respectively, 141 and 193. The average roughness factor of the concrete pavements constructed prior to 1923 is 196, while the average roughness factor for those constructed in 1923 and subsequent years is 115, showing that very great progress has been made in constructing smoother pavements. In Table I is shown the data for a section of pavement fairly typical of those constructed 6 and 7 years ago, while in Table II is shown the data for a section of pavement constructed in 1924.

TABLE I

State—Michigan
Date—August 20, 1925
Road—Petoskey-Charlevoix—F. A. Project 27
Type—Concrete
Beginning—Petoskey end of pavement. Odometer 46.0
46 — 47 — 252 — 252
46 — 48 — 510 — 258
46 — 49 — 754 — 244
46 — 50 — 983 — 229
46 — 51 —1332 — 349
46 — 51.4—1490 —End of pavement
Average per mile—276

TABLE II

State—Michigan
Date—September 22, 1925
Road—Grand Rapids-Lansing F. A. Project 113
Type—Concrete
Beginning—Junction M-16 and M-21. Odometer 58.0
58—59 — 90— 90
58—60 — 180— 90
58—61 — 261— 81
58—62 — 345— 84
58—63 — 447—102 Hills
58—64 — 545— 98
58—65 — 644— 99
58—66 — 728— 84
58—67 — 813— 85
58—68 — 895— 82
58—69 — 976— 81
58—70 —1078—102 Hills
58—71 —1161— 83
58—71.6—1219—End of Pavement
72.0—P. M. R. R. Crossing
Average per mile—89.6

In each of the three states it was noticed that the first mile constructed was generally the roughest mile in the section. The data shown in Table III illustrates this fact most strikingly.

TABLE III

State—Michigan
Date—August 21, 1925
Road—M-11 Grand Haven-Holland
Type—Concrete
Beginning—R. R. Crossing in West Olive
Odometer—21.0; Roughometer—1762
21—22—2145 (First Mile)
21—24—2567—271
21—25—2695—128
21—26—2807—112
21—27—2922—115
21—28—3048—126
21—29—3204—156
30.3 Intersection M-11 and M-51

The average roughness factor of the roughest mile in each of the 48 sections of concrete pavement is 175, and of the smoothest mile in each section is 107—a difference of 68. This difference in 34 sections in Illinois is 65 and in 13 sections in Indiana is 67. This would seem to indicate that very careful supervision should be exercised during the construction of the first mile and that.Ystetaoinshrdlucmfwyp should be avoided as is possible by awarding contracts early in the season and of such lengths as may require the entire season to construct.

In general it was found that a pavement is smooth or rough all the way across, although in a number of instances a considerable difference between the right and left sides were found. The data shown in Table IV shows this general fact.

TABLE IV

State—Michigan
Date—September 24, 1925
Road—Monroe-Toledo F. A. Project 73
Type—Concrete
Beginning—North end of pavement

Mile	West Side	East Side
1	81	89
2	91	97
3	88	89
4	101	121
5	69	77
6	76	86
7	74	84
8	85	96
9	89	97
10	82	81
11	83	82
12	85	88
13	79	81
14	94	85

Average per mile—West side—84.0
East side—89.5

"How smooth should future pavements be required to be?" is a question that may have occurred to you. It certainly would not be unreasonable to say, as smooth as the smoothest that have been constructed. In Tables V and VI and shown the data for the smoothest sections of pavement found in Michigan and Illinois.

TABLE V

State—Michigan
Date—August 21, 1925
Road—Muskegon-South on M-11 F. A. Project 117
Type—Concrete
Beginning—1.4 miles south of Mono Lake Ice Co. Bldg. Odometer 3.0

3—4— 63— 63
3—5—134— 71
3—6—200— 66
3—7—319—119
3—8—428—109

Average first three miles—66.7

TABLE VI

State—Illinois
Date—August 23, 1925
Road—Harvard-Woodstock S. B. R.—19
Type—Concrete
Beginning—End of pavement at Harvard. Odometer 13.0

13—14— 60—60
13—15—127—67—Bdge. 4
13—16—187—60
13—17—250—63
13—18—307—57
13—19—370—63
13—20—429—59
13—21—491—62
13—22—550—59
13—23—618—68

Average per mile—61.8

Convicts to Build Maine Highway.—The Maine State Highway Commission will pay $1.75 per day of 9 hours for the labor of each inmate of the State Prison to be employed in the construction of two miles of state highway between West Rockport and Union. This price will be subject to revision.

Financing City Improvements for 20 Years.

The Board of Aldermen of New Haven, Conn. has authorized Mayor Tower to appoint a non-partisan committee to draw up a programme for financing permanent improvements needed by the city for the next 20 years.

Big Paving Job in Cuba

Preparations for initiating construction of the Central Highway in Cuba will be rushed, it was decided at a meeting of President Machado's Cabinet in Havana, April 14. Conditions for bids will be drawn up immediately. An advance announcement states that bids will be accepted for sections or all of the highway, provided the contractors' methods of financing do not conflict with Article X of the Public Works Law which follows:

ARTICLE X. Time for Executing the Works, Form of Doing so and Priority. The foregoing works and any others which the National Executive may consider of public convenience, shall be effected, subject always to the requirement of competitive bidding, at the times that said Executive may consider advisable, effort being made to have those of greatest importance or necessity executed within the period of four years. For that purpose, the Executive shall adopt the system and procedure which he may consider most efficacious; but at no time may he contract them in such manner that the annual payments therefor, whether in part or in whole, can not be taken care of within each fiscal year from the normal revenues calculated for that year, from the Special Fund for Public Works created by this law, so that it will not be necessary to issue certificates of indebtedness or other similar documents for the payment of obligations contracted, it being understood that subject to that limitation he is authorized to make, within those four years, all the contracts which he may consider advisable, providing always that in their fulfillment they are adjusted to the conditions aforesaid, even though the contracts are to be executed subsequently to the four years mentioned, within a period not greater than ten years, as a charge to the normal revenues produced by the taxes authorized by this Law, in each one of those years. In the execution of the works proportionate distribution thereof shall be arranged, in each year, among the provinces, taking into consideration the population and requirements of each one, care being taken to see that the order established by Law is followed, and said preference being adjusted in all cases to the greater importance or necessity of the works and to the most equitable distribution of the available funds; it being considered imperative to begin the plan with the construction of the Central Highway, the Acqueducts, Sewerage Systems, Paving and School-Houses. The President shall endeavor to subordinate the volume of work to the requirements of the sugar industry during the crop season; adopting for such purposes whatever measures may be necessary. In the contracts which are executed the Contractor shall agree to submit himself to Cuban Judges and Tribunals, and in no case can he allege his status as a foreigner, or bring any claims against the Cuban Government except through the National Tribunals.

Council Manager Plan for Newark, N. J.—The Chamber of Commerce of Newark, N. J., is conducting an educational campaign for the adoption by this city of the Council-Manager plan of municipal government. The city has been under the commission form of government for some years.

Licensing Contractors in New Jersey.—A bill has been introduced in the New Jersey legislature providing for the licensing of contractors engaged in public works construction operations in that state.

5-Mile Bridle Path at New Orleans.—The city of New Orleans, La., is building a 5-mile bridle path in City Park, financing it by popular subscription.

A 10,000 Sq. Yd. Per Day Paving Plant

Outfit Used by the Highway Construction Company on Its 550,000 Square Yard Bituminous Pavement Contract at Miami, Fla.

One of the largest single contracts for mixed bituminous pavement ever let was awarded last winter to the Highway Construction Co., of Cleveland and Elyria, O. The contract called for the laying at Miami, Fla., of approximately 550,000 sq. yds. of pavement, a portion of which was sheet asphalt and the balance asphaltic concrete. In order to carry out the project in accordance with their plans, arrangements had to be made to put down about 10,000 sq. yds. of pavement per day, a daily yardage, by the way, which is believed to be the largest ever planned for by any one contractor.

The equipment decided on was two 5,000 sq. yd. capacity semi-portable plants together with the various auxiliary equipment for use in connection with the plants. The plants were purchased from Warren Bros. Co., Boston, Mass. the contract with that company calling for the building and shipping of the two plants within 30 days from the time the order was received. The contract also included together with the two plants, two 60,000-gal. capacity composite type storage tanks with individual pumping outfits, a 20,000-gal. capacity fuel oil storage tank, a 1,000-gal. capacity working supply fuel oil tank, fuel oil pumping system, and a 150 H. P. boiler to furnish steam for operating the storage tanks and for various other plant operations. Power for operating the two paving plants is furnished by individual 100 H. P. motors.

Arrangement of Equipment.—The arrangement of this equipment consisted in placing the two plants 150 ft. apart on centers. Each of the 60,000-gal. capacity composite type storage tanks was located adjacent to the plants in the space between, the fuel oil storage tanks, pumping outfit and the steam boiler being located mid-way between the two storage tanks, therefore, two ample cold material storage compartments, each located adjacent to the elevators of each plant. A large dust storage shed placed between the two plants provide ample indoor storage for fine filler. Railroad tracks and industrial crane tracks specially arranged provide ample facilities for getting in raw materials and the handling of these materials by crane.

Each of the two 5000-yd. capacity semi-portable plants, as illustrated by accompanying cut, consists in the main of two internal heated oil burning Pacific type driers 56 in. in diameter and 24 ft. long completely equipped with cold material charging elevator, exhaust fan, exhaust piping, dust piping, supporting frame and all transmission.

A dust tight, steel encased, large capacity hot material elevator receives the product from both driers and elevates it to the screen and bin. The elevator is of the chain belt type equipped with Manganese steel elevator chain and large capacity elevator buckets, this elevator having ample capacity to handle the entire produce of both driers. The dried and heated sand is discharged from the elevator into a heavy duty rotary screen equipped with five screen sections, these screens of the proper mesh to produce the required grading of the mineral aggregate. The fifth screen section is a receiving screen upon which the material from the elevator is first deposited. This receiving screen relieves the other screens of undue wear and facilitates rapid separation of the coarse and fine material as it first enters the screen.

Hot Material Bins.—The hot material storage bins are of 32 cu. yd. capacity divided into four compartments properly proportioned, each of these compartments having an individual outlet. The product of each screen section is depsited in a corresponding compartment of the hot material storage bin and a by-pass is provided through which over size rejections deliver into a 5-ton capacity elevated steel rejection hopper so placed that it will discharge immediately by gravity into trucks.

A large capacity suspended hopper type weigh box is provided located beneath the bin outlet gates and above the mixer, this weighing box being equipped with a multiple beam scale which permits of accurate and rapid weighing of the various sized mineral aggregate.

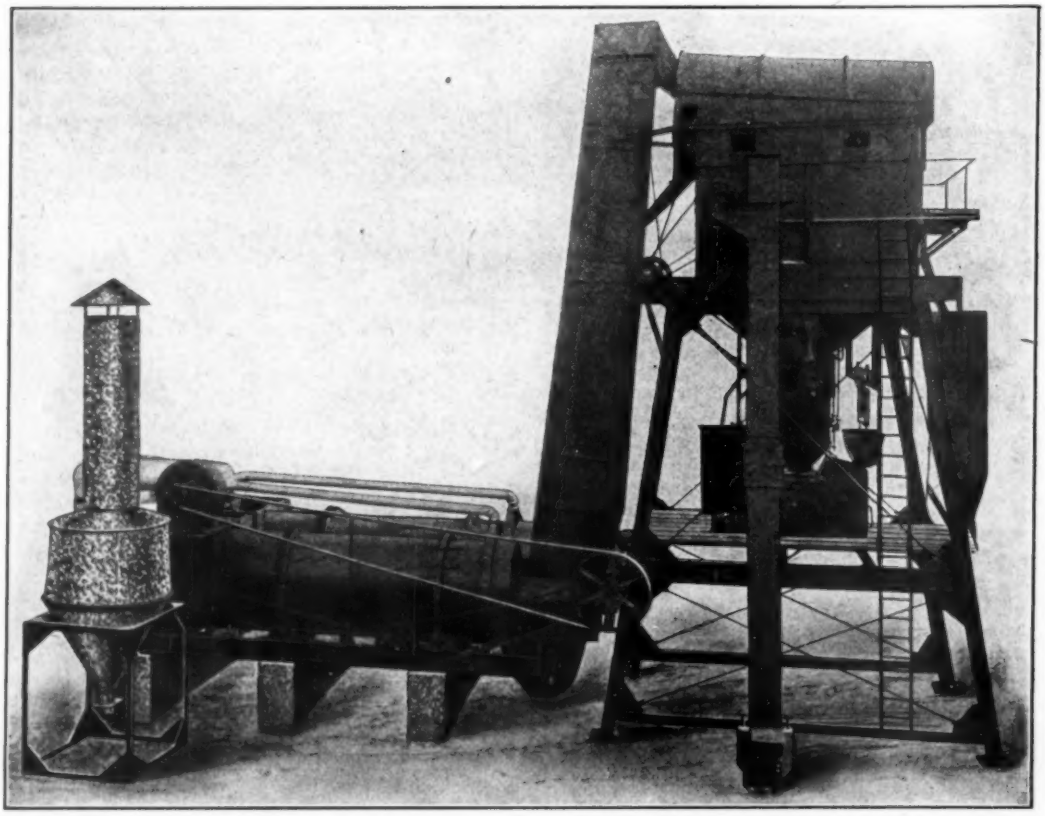
The Mixer.—Located directly beneath the suspended weigh-box is a twin pug mixer having a capacity to mix a batch of 2000 lb. This mixer is provided with a steam jacket and a steam opening device and is equipped with a specially designed cover to minimize the escape of dust and the loss of heat. An interesting feature of the mixer cover is the asphalt charging tray built into it through which the hot asphalt is poured from the weighing bucket. The asphalt flows through a number of small holes in the bottom of this charging tray, the number and size of these holes being such as to permit uninterrupted flow, the asphalt, however, at the same time effectually

sealing these holes in such a manner that dry fine material and dust cannot escape. This results in a decided reduction of the dust nuisance about the plant. This mixer is equipped with Manganese steel mixer arms with detachable blades composed of a special alloy, very tough, gray iron and the high carbon steel liners of this mixer are of a design that permits reversing their positions when they have become unduly worn and thus greatly prolonging their usefulness.

tower being securely stiffened by heavy tie rods and turn buckles.

An inspection platform around the bin is provided and there is also provided a steel ladder making this platform easily accessible.

Together with each of these plants there is provided a large galvanized iron dust collector with special dust piping leading to the discharge end of the driers and to the exhaust fan.



Semi-Portable Asphalt Plant Manufactured by Warren Bros. Co. for Highway Construction Co., for use at Miami, Fla. Two of These Plants Are Worked Together

Each of the two 5000-yd. units is equipped with an elevated steel plate dust storage bin of 2½ cu. yd. capacity. Enclosed Helicoid worm conveyors deliver the dust or fine filler to the weighing box.

A steel encased dust elevator equipped with Salem buckets and enclosed boot and head chute conveys the dust from the dust storage house to the dust storage bin.

A very substantial structural steel tower designed with bolted field connections supports the bin and screen, weigh box, mixer, rejection hopper, etc., in their proper positions, this

A 40-gal. capacity suspended type asphalt weighing bucket equipped with dial scales is furnished in connection with each plant.

Asphalt Storage Tanks.—Working supply and storage asphalt for each of these plants is provided by a 60,000-gal. capacity composite type asphalt storage tank. These tanks are of special design having a central heating chamber equipped with three separate electric welded steam coils, the total radiating area of which provides an ample quantity of properly heated asphalt to supply each plant. This asphalt is pumped from the central heating

chamber to the weighing bucket by means of a direct connected steam driven steam-jacketed asphalt pump located near the tank. These tanks are so designed that as the hot material in the central heating chamber is pumped over to the plant this material is constantly replaced by inflowing asphalt from the outer or main storage compartment. Each of these tanks is equipped with a special rapid unloader installed in conjunction with the pump suction line that permits pumping sufficiently heated asphalt in from one to one and one-half hour from the time that steam is turned on to the coils in the central heating chamber. Under ordinary conditions it is never found necessary to heat the outer or main storage compartment, although steam coils are provided for this purpose should occasion arise for using them. These tanks are circular, constructed of steel plate designed for bolted connections at the joints and for installation on a concrete foundation and can be entirely salvaged when moving the equipment.

One 150 H. P. economic type boiler provides steam for heating the asphalt tanks, mixer, jacket and asphalt lines and for operating the steam opening device on the mixer for both plants.

The 20,000-gal. capacity fuel oil storage tank and the 1000-gal. capacity working supply fuel oil tank are equipped with steam heating coils and a central fuel oil pumping outfit pumps the fuel oil to both burners of each plant.

It required 11 large capacity railroad cars to move this entire equipment.

With these two plants running at full capacity there will be employed daily approximately 100 tons of asphalt (approximately 2½ car-loads) and 900 tons of sand and stone.

A very interesting point in connection with this equipment is that it was all designed and built in thirty days.

Wide Roads

Communities, especially the larger ones, in every part of the country, are wrestling with the problem or revising their highway systems to accommodate increased traffic. The large number of projects, either completed, under way or proposed, that call for the widening of existing highways or the construction of new wide highways is an indication of the widespread need for traffic surfaces of adequate width.

A few of the projects of this nature are listed in April Concrete Highway Magazine as follows:

New York: Sections of the Albany Post Road and the Boston Post Road have been rebuilt 40 ft. wide.

The Erie County Boulevard, a wide concrete pavement encircling Buffalo is partly built.

Connecticut: Sections of the Boston Post Road have been widened to 40 ft.

Pennsylvania: The Lincoln Highway from Philadelphia to Chester is to be widened to 55 ft. and from Chester to Harrisburg to 40 ft.

Street widening is planned in Philadelphia to provide approaches to the Camden Bridge.

New Jersey: The White Horse Pike from Camden to Atlantic City is to be widened to 40 ft.

Michigan: All roads on the Wayne County highway system to be widened to a minimum of 40 ft. Super-highways in Wayne, Oakland and Macomb Counties to be built with 88 ft. of traffic surface on 204-ft. right-of-ways.

A 40-ft. concrete pavement is to be built from Pontiac to Saginaw. It will connect at Pontiac with the Wider Woodward Ave. Super-highway to Detroit.

Illinois: Four lane highways are planned for important roads in Cook, DuPage, Kane and Lake Counties in the Chicago Regional Area. Bond issues totaling $15,045,000 for widening streets and building important bridges in Chicago was voted April 13.

Wisconsin: Milwaukee, Racine, Kenosha and Waukesha Counties are planning or undertaking the construction of four lane pavements, either as 40-ft. roadways or as two 20-ft. roadways separately by a park strip.

Indiana: The Ideal Section of the Lincoln Highway, 40-ft. wide, shows the type of highway needed today. A movement is under way to widen the Dunes Highway to 40 ft.

California: There is a great deal of activity in Southern California in wide highway and street construction. Examples are Pico Boulevard, 75 ft. wide; Cahuenga Pass Road, 72 ft. wide and the Foothills Boulevard widened to accommodate three lanes of traffic. The Coast Highway leading south from San Francisco has been widened to accommodate the traffic it bears.

Good Roads Movement Progresses in Peru.—Following closely the Pan-American Roads Conference held in Buenos Aires in October, 1925, the government of Peru has just issued a decree compelling all primary schools and colleges, both public and private, to include a course on good roads in school curriculums, the U. S. Department of Commerce has been advised. The purpose of the decree, as stated officially, is to inculcate in the pupils a strong sentiment for road construction, road upkeep and development, and a sense of duty to cooperate in the development of good roads within the country.

Methods of Constructing Asphalt Tennis Courts

Drainage System—Grading—Foundation Course—Asphaltic Concrete Surface —Quantities of Material Required

By W. E. ROSENGARTEN
Engineer, The Asphalt Association, New York, N. Y.

Interest in lawn tennis has been increasing in recent years and with it there has developed a strong desire for more nearly perfect court surfaces. The qualities which are sought are greater smoothness than can usually be obtained in the ordinary sand clay tennis court, and greater firmness and resiliency. Paved surfaces, particularly those of asphalt, permit of fast and true play without serious fatigue or injurious effect upon the players. An important consideration from the standpoint of ultimate economy is the construction of a surface that can be kept in perfect condition at small labor and expense throughout the playing season.

Of the many thousand of tennis courts that exist throughout the United States only about 10 per cent have been given hard, smooth, paved surfaces and the trend toward the best in tennis courts is, I believe, therefore, only in its initial stages. England has made extensive progress in this direction and has not only reached a high degree of efficiency in constructing and maintaining asphalt tennis courts but has obtained some very beautiful effects by incorporating into the finished surface red crushed tile, or treating it with a green solution, thus presenting a very pleasing color scheme either contrasting or harmonizing as desired, with the borders and terraces of green turf.

While there are asphalt paved courts located at Detroit, Mich; South Bend, Ind; Calgary, Canada, and other points, they are most common in the Pacific Coast section of the country. Their general use there is due largely to the fact that in California is obtained an abundance of petroleum which yields asphalt, a popular and readily available local product. Because of the greatly increased use of asphalt for paving and roofing within the past few years and the establishment of asphaltic plants at convenient points, sources of supply and competent construction facilities for asphalt courts are now within easy reach of any community.

Advantages of Asphaltic Tennis Courts.—Asphaltic tennis court surfaces are waterproof and, in consequence, not only are the courts available for play within 10 or 15 minutes after a rain but the surface is thoroughly protected against washing or disintegration such as is frequently caused by heavy downpours on sand clay or earth courts. A maximum smoothness is obtainable in the asphalt playing surface and this smoothness is retained throughout the play on account of the fact that the powerful adhesive character of the asphalt prevents any displacement of the surface material. Asphalt is a flexible and resilient material and makes possible long and continuous periods of play without tending to tire out or stiffen the players. The freedom of the surface from sharp, angular fragments or from rigid, gritty texture tends to conserve the soles of the players' shoes as well as the tennis balls, since there is practically no abrasion.

While the original cost of an asphalt court is somewhat greater than a sand clay or gravel court, the initial cost is retrieved in a very short time because a properly constructed asphalt tennis court requires practically no upkeep.

Drainage System.—Proper drainage is of primary importance for an asphalt tennis court just as it is in the proper construction of a highway. In sandy or gravelly soil the drainage problem is not serious and the water drains away easily and naturally. Soils in which clay predominates, however, will retain water and unless proper drainage facilities are provided the wet subgrade under the surface will not provide sufficient support for the pavement. Where such a soil is encountered drainage is obtained by digging a ditch 2 or 3 feet deep along each side of the court and giving to these ditches a slight grade or fall in the direction of the general slope of the ground. In the bottom of these ditches there should be laid a small-sized, open-joint tile after which the trenches should be back-filled with broken stone to within a few inches of the surface. This drainage system will collect the ground water and lead it away from the subgrade. Drainage of surface water from the court itself will be obtained by giving the finished

surface a slight slope of one inch for each ten feet of distance.

In the construction of the tennis court the subgrade should be leveled and finished to an elevation such that when the playing surface is applied the latter will be flush with the shoulders of the surrounding sod, thus permitting an uninterrupted drainage of surface water after the court is completed. Where fills are made they should be thoroughly compacted and allowed to stand until they have been subjected to several heavy rain falls before surfacing is attempted. The paved area of a tennis court should be 60x120 feet. As the outside dimensions of a double playing court are 36x78 feet, such a paved area will afford ample room for play outside of the lines.

Foundation Course.—After the grading and drainage work has been completed and the subgrade is dry and compacted, a foundation course of steam cinders of from 4 in. to 6 in. in thickness may be applied to good advantage. Ashes from house furnaces are not desirable for this purpose. The cinders should be thoroughly compacted by sprinkling with water and rolling. Too much stress cannot be laid upon the importance of a thoroughly rolling since it constitutes insurance against trouble later from the settlement of the paved area. Equal, if not better, foundations can be obtained through the use of crushed stone, gravel, slag or similar local materials, or from a 3 in. bed of portland cement concrete. A superior type of foundation may be laid if an asphalt paving plant is accessible by laying a mixture of stone and sand bound together with asphalt according to up-to-date paving specifications and at a thickness of about 2½ in.

The Surface.—As suitable a type of surface course as can then be laid upon the foundation is the sheet asphaltic pavement similar to that which is commonly laid on great thoroughfares like Fifth Ave., New York. This consists of a mixture of hot sand, limestone dust and ashphalt cement, and should be laid to a thickness of from 1 in. to 1½ in. This material should be prepared at a mixing plant. Asphalt paving contractors are, of course, quite familiar with this type of construction and complete information can be obtained from them as well as the local engineer in charge of city street or country highway paving.

Where the base course is of broken stone or cinders, it will be desirable first to lay what is known as a binder course about 1 in. in thickness upon the foundation before laying the sheet asphalt surface course. This binder course is similar to the asphaltic base mixture mentioned above. It consists of stone ¼ in. to ¾ in. in size, which is mixed with sand and asphalt cement and laid in the same manner as later described for the sheet surface course. The binder course mixture should have the following proportion by weight:

Stone retained on a sieve having 10 wires per inch	60 to 80%
Sand passing a sieve having 10 wires per inch	15 to 35%
Asphalt cement (pure bitumen)	4 to 6%

The sheet asphalt surface course, which will not require the above described binder course if the foundation be of asphaltic concrete or portland cement concrete, should be from 1 in. to 1½ in. in depth. In order to obtain the best results a carefully graded sand should be employed. This, when mixed with the asphalt and limestone dust, which should pass a sieve having 200 meshes per inch, should give a mixture which will have the following composition by weight:

Sand passing a sieve having 10 meshes per inch and retained on a sieve having 40 meshes per inch	10 to 40%
Sand passing a sieve having 40 meshes per inch and retained on a sieve having 80 meshes per inch	22 to 45%
Sand passing a sieve having 80 meshes per inch and retained on a sieve having 200 meshes per inch	12 to 30%
Dust passing a sieve having 200 meshes per inch	10 to 20%
Asphalt cement (pure bitumen)	9.5 to 12%

The asphalt cement for both the binder and surface courses should be of a consistency such as to show a 50 to 60 penetration test when used in warm climates and from 60 to 70 when used in cold climates where the temperature falls below 10 degrees F.

The above mixture should be prepared at a paving plant where the sand and asphalt can be heated to approximately 350 degrees F. A temperature above 400 degrees F. is not desirable since it tends to injure the asphalt. The quantity of asphalt paving mixture necessary for one or two tennis courts would hardly be sufficient to justify the setting up of an asphalt paving plant, it is therefore desirable to obtain the mixture either from a municipal plant or a contractor's street paving plant in the vicinity. After it is prepared the mixture can be hauled hot by truck any distance ranging up to 20 miles if necessary.

Where a hot-mix asphalt plant is not available a cold mix may be made with especially treated asphalt products known as emulsified asphalts and cut-back asphalts which are liquid at ordinary temperatures. Satisfactory materials of this kind are on the market and can be mixed with unheated sand to produce a paving mixture that will harden in a few days and produce a stable surface.

Placing Surfacing.—The surfacing material should be dumped from the trucks upon boards or platforms from which it can be spread by shovels over the prepared foundation course and then raked to a depth such that after rolling it will be at least 1 in. thick. Rolling should follow shortly after the spreading and while the mixture is still pliable. Thorough compression is essential and while heavy hand

rollers will give satisfactory results it is preferable to use a power roller of at least 5 tons' weight if one is available. After thorough compaction has been obtained it is desirable to sweep over the surface a sprinkling of limestone dust or portland cement and to finish the surfacing with a final rolling in all directions diagonally and longitudinally.

An asphalt surface does not produce glare under sunlight. It has a dark gray color that is restful to the eye. In some cases, however, it has been thought desirable to tint the surface with a green cromic oxide paint to give it more nearly the appearance of the grass court. Various other solutions are also to be found on the market for this purpose and can be applied by means of a forced spray. The lines are marked out by means of stencils with a solution in white. The best results are obtained by applying the solution in two thin coats. The second coat should not be attempted until after the first has thoroughly dried. On some courts a special finish has been used which gives the surface a pleasing color of deep red.

Penetration Method.—The penetration method of construction is also used sometimes for court surfacing. The usual procedure is to spread a uniform course of crushed stone 1½ in. to 2 in. in thickness upon the foundation of cinders, crushed stone or gravel. The stone used should be ¾ in to 1¼ in. in size and should be rolled dry sufficiently to set it in position. Over the dry stone, which should present a firm, true surface of even texture, is poured asphalt cement heated to about 300 degrees F. The asphalt cement should be of a consistency that will give a penetration test of 100 to 150. About 1-6 gal. of asphalt per square foot will be required completely to coat the stone in this surface course. A cover of stone chips usually is spread over the surface, followed by thorough rolling. A hot hand-roller has been found to give sufficient compression, but a 5-ton roller is preferred. In order to obtain a smoother surface it is sometimes desirable to apply a second light coating of asphalt cement. This treatment is but one-fourth as much as the first and is covered with fine stone chips and finished by thorough rolling. The penetration type courts have turned out to be very satisfactory but since the surface is not as accurate as that obtained from the mixed types, the penetration court generally is not used for tournaments.

Table I gives the quantities of materials required for the courts above described.

Asphaltic Oil Treatment.—Another and less expensive method of obtaining a desirable tennis court surface is that of the treatment of a sand clay or gravel base with an asphaltic oil. For a new court it is preferable to construct in the usual manner a gravel or sand-clay base and use it for several months so that it will become thoroughly set. The surface is then dragged and carefully brought to a true plane. Upon this is sprayed a light coating of asphaltic oil at the rate of about 0.03 gal. per square foot, or a total of about 5 bbl. for a court 60 ft. by 120 ft. This surface is then covered with fine stone chips or coarse sand and is allowed to stand for 24 hours. About 1½ to 2 tons of cover material are required to each barrel of asphaltic oil used. A roller, if available, may be used to advantage. The asphaltic material may be a liquid which can be applied cold, or on a gravel surface a somewhat heavier asphaltic oil which must be heated before application can be used. When the lighter oil is used, renewed applications will be required about every year, while with the heavy hot oil several years may intervene between applications. And after several treatments a lasting surface will have been built up.

TABLE I

QUANTITIES OF MATERIALS REQUIRED FOR ASPHALTIC TENNIS COURTS

(Per square foot of paving 1 in. thick)

Material	Compacted foundation per 1 in. thickness	Asphaltic binder course per 1 in. thickness	Sheet Asphalt surface per 1 in. thickness	Penetra. macadam surf. per 1 in. thick.
Crushed Stone	10 lb.	8.6 lb.	.....	12.0 lb.
Sand	.....	3.3 lb.	8.5 lb.	.....
Stone Dust	.....	.....	1.6 lb.	.....
Ashpalt Cement	.....	.07 lb.	1.2 lb.	0.9 lb.
Total	10 lb.	12.6 lb.	11.3 lb.	12.9 lb.

Note:—
Stone weighs (loose) 2400 to 2800 lb. per cu. yd.
Sand weighs from 2300 to 2600 lb. per cu. yd.
Asphalt weighs from 8.3 to 8.8 lb. per gallon.

Motor Vehicle Production in 1925.—Production of motor vehicles of all classes last year totaled 4,157,830, with a wholesale factory value of $2,934,488,639. This was an increase, the U. S. Commerce Department reports, of 6.9 per cent in number and 12.4 per cent in value as compared with 1923, when the last census was taken. Total production by establishments engaged primarily in the manufacture of motor vehicles, exclusive of body, parts and accessory makers, reached $3,371,855,805 in 1925, including 3,655,048 passenger vehicles valued at $2,527,366,148; 13,627 public conveyances worth $39,454,025; 1,185 government and municipal vehicles worth $10,183,227; 487,970 business vehicles worth $357,485,239; 8,531 trailers worth $3,449,017, and other products worth $433,919,149. The average unit values of both open and closed cars decreased between 1923 and 1925, but the larger proportion of closed cars manufactured, which jumped from 35.1 per cent in the earlier year to 58.3 per cent last year, was given as the explanation for the higher value increase compared with the numerical gain.

Labor Laws on Highway Work

Abstracts of Regulations and Laws of Pennsylvania Department of Labor and Industry

The Pennsylvania State Highway Department has issued a special bulletin giving abstracts from the laws and regulations enforced by the Department of Labor and Industry in order that contracting firms bidding on highway projects or firms securing highway contracts will be able to know what equipment may be brought into the State of Pennsylvania and how such equipment must be guarded. Information is also given concerning the compensation and employment laws enforced by the Department of Labor and Industry.

The bulletin follows:

Boilers.—No boiler can be operated in the state which does not have a certificate of operation furnished by the Department of Labor and Industry.

To obtain a certificate of operation, boilers must be inspected internally and externally by an insepctor holding a Pennsylvania boiler commission and who is employed either by an insurance company or by the Department of Labor and Industry.

All boilers if built since July 1, J916, must have been constructed in accordance with the Pennsylvania (A. S. M. E.) Boiler Regulations and must be stamped with the A. S. M. E. symbol and either with the Pennsylvania standard stamp or the stamp of the National Board of Boiler and Pressure Vessel Inspectors.

If not stamped as above, only the following boilers will be permitted to be operated in Pennsylvania:

Those stamped with the A. S. M. E. symbol and with the stamp of another A. S. M. E. state, provided the boiler was inspected during construction by an approved Pennsylvania inspector.

In case the boiler was built prior to July 1, 1916, it cannot be operated in Pennsylvania unless the boiler was in the state prior to and has been operated in the state since July 1, 1916, and has not changed ownership.

Guarding of Equipment.—All pulleys, all belts, ropes and chains and all gears and sprockets shall be guarded in accordance with the regulations pertaining to mechanical power transmission.

Railings and toe boards shall be installed along the open sides of all floors, platforms and runways which are over 6 ft. above the ground level. Railings must be 42 in. high with a mid-rail 21 in. high and must be constructed of pipe, angle iron or wood according to the Regulations of the Department of Labor and Industry. Toe Boards must be at least 6 in. high and of such materials and dimensions as are specified in the Regulations mentioned above.

Circular rip saws and circular cross-cut saws shall be equipped with hoods and spreaders to prevent personal contact with saws. (See Woodworking Regulations.)

All moving parts of pumps, compressors, stationary engines and similar apparatus, shall be guarded according to Regulations.

Health.—Drinking water Regulations:

"Where possible, a sufficient quantity of pure and wholesome drinking water of a quality approved by the Pennsylvania Department of Health shall be provided by contractors for employes engaged in contracting operations.

Where it is not possible to supply drinking water which has been approved by the Pennsylvania Department of Health, contractors shall supply a sufficient quantity of pure and wholesome water and shall further be responsible for the testing of such water."

Employment.—No minor under 14 years of age shall be employed or permitted to work in any occupation.

No minor under 16 years of age shall be permitted to work who has not obtained from the proper school authorities, an employment certificate as required by the Child Labor Law.

No minor under 16 years of age shall be permitted to work for more than 51 hours in any one week, or more than 9 hours in any one day, or before 6 o'clock in the morning or after 8 o'clock in the evening.

No minor under 18 years of age shall be employed in oiling or cleaning machinery in motion; at switch-tending, at track-repairing or as a chauffeur of an automobile.

No minor under 18 years of age shall be employed at any occupations which the Department of Labor and Industry may from time to time declare to be dangerous.

Every employment agency furnishing men to state highway contractors must have a private agency license which is issued by the Department of Labor and Industry, under the terms of Act 397, Pennsylvania Statutes, 1915, P. L. 888.

Every commissary owner or labor camp manager who furnishes employes to state highway contractors for which service he is paid by commission or upon a per capita basis, must have a private employment agency license issued by the Department of Labor and Industry under the terms of Act 397, Pennsylvania Statutes, 1915 P. L. 888.

Labor camps operated by state highway contractors or by their commissary and camp owners or managers, must be in accordance

with the provisions of the labor camp regulations of the Department of Labor and Industry, Commonwealth of Pennsylvania.

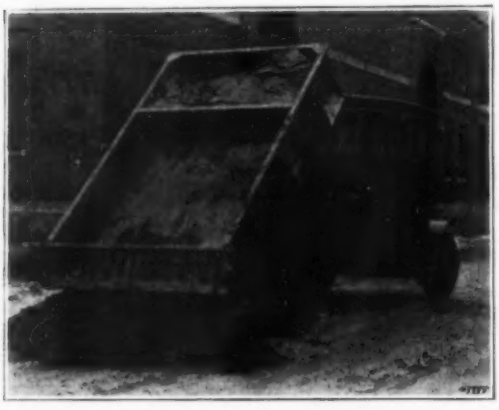
Workmen's Compensation.—Every accident during the course of employment resulting in injury which causes the loss of two or more days to the injured, must be reported to the Bureau of Workmen's Compensation, Department of Labor and Industry.

The Workmen's Compensation Act may be either accepted or rejected. In case of rejection, a specific agreement in writing must be entered into at the time of hiring between employer and employee. The employer must notify the employee and the Bureau of Workmen's Compensation of such rejection.

If the Workmen's Compensation Act is accepted the employer must insure to cover liability to his employes and may do so in the state insurance fund, a stock insurance company, a mutual insurance company or carry his own insurance if permitted by the Bureau of Workmen's Compensation.

Special Truck for Emergency Street Repair Work

In most cities at least two trucks are employed to make emergency street paving repairs—one a dump truck containing the paving materials and a second truck to carry men and tools.



Wood Hydraulic Hoist and Body Used by City of Detroit in Emergency Street Repairs

The city of Detroit has found it economical to combine the entire equipment on one truck. This unit, as illustrated, has an extra long chassis to provide sufficient space in the cab for the men and tools, and a compartment in the dump body for extra tools, canvas covering, lanterns, etc. The men, tools and material all arrive at the same time.

Concrete Pile Trestles

In a paper presented March 4th at the South-West Road Show and School at Wichita, Kan., G. W. Mayo, Highway Bridge Engineer, U. S. Bureau of Public Roads, gave the following:

A type of construction very largely used in the wide over-flow valleys in the southern states and which is also well adapted to what might be termed the "Wandering Streams" common to such States as Texas, Oklahoma and Kansas, is the concrete pile trestle. By "Wandering Streams" is meant the rather shallow rivers with unstable stream beds of shifting sand and which are so difficult to keep within the bounds of their natural banks. In such cases where the stream bed is fairly well defined, it will generally be most economical to use a series of steel truss spans over the main channel with concrete pile trestle approaches as may be needed to fit the case and adequately care for the maximum flood waters. Comparatively cheap types of bank protection work built in connection with such bridges tend to restrict the main channel to fairly definite lines, provided adequate opening is afforded for the maximum flood waters. Concrete pile trestle construction requires extremely heavy equipment for the best results and unless there is a sufficient volume of work to justify such equipment the cost will be excessive. Where this type of construction can be used in connection with steel spans of moderate length concrete pile bents as supports for the steel spans will do away with costly wet excavation and result in a very pronounced economy. Construction of this type should not be used where there is much danger accumulating drift.

Where the stream bed is of a shifting nature, as above mentioned, no reliance can be placed on "skin friction" on the piles and the tips must be driven well into an underlying material of sufficiently firm nature to provide a satisfactory foundation. Fortunately these streams in this section of the country are generally underlaid with a stiff indurated clay or soft shale at fairly moderate depths, and, by using a sufficiently heavy equipment, satisfactory results can generally be obtained. A bridge of this type some 3000 ft. in length will shortly be put under construction over the Red River between Texas and Oklahoma. The underlaying material in this case is a rather hard blue shale and the specifications require a penetration into this material of from 5 ft. to 8 ft. In this case the piles are to be steel shod and pilot holes are to be drilled, if necessary. The specifications on this job also require the use of a steam hammer equal in capacity to the No. 0 Vulcan hammer which has a gross weight of 8¼ tons and a striking energy of 30,000 lb. per blow.

The Strengthening of Existing Masonry Bridges

English Methods in the Use of Reinforced Concrete Described in Paper Presented at Conference of British Institution of Municipal and County Engineers

By C. G. MITCHELL and C. S. CHETTOE
Of Roads Department, Ministry of Transport

Strengthening Arch Ring of Brick and Stone Arches.—The best method of strengthening the arch ring is generally to construct a plain or reinforced concrete relieving the arch above the existing arch ring. This relieving arch should be given a good bearing on the old abutments, as shown in Fig. 1. It would, of course, be necessary to investigate the strength of the abutments to discover whether they were capable of withstanding the additional thrust. In structures of the arch type, in which rise, span and loading are constant and the amount of inertia of the cross-section is constant throughout, the ring deflections at similar points are inversely proportional to the modulus of electricity multiplied by the moment if inertia. Hence, if deflections are the same the loadings on the arches would be directly proportional to E multiplied by I. In brick arches I was constant throughout the ring, and it would in most cases be constant throughout the relieving arch. The two would be in contact, so that deflections would be the same in both. Rise and span also would be approximately the same, so that

$$\frac{\text{load taken by old arch}}{\text{load taken by relieving arch}} = \frac{E \times I \text{ (old arch)}}{E \times I \text{ (relieving arch)}}$$

From this the approximate required dimensions of the relieving arch could be obtained. The existing arch would carry the dead load of the relieving arch in addition to its own weight. If the existing abutments were not strong enough to take any extra thrust and a relieving arch was constructed without abutment (Fig. 2) this would act merely as a slab except for friction between it and the old arch, and as it would take but little load on itself was not recommended.

Method Where Further Stresses Cannot Be Put on Abutment.—A method which had been adopted where it was not desired to put further stresses on the abutments is shown in Fig. 3. Unless the material AA between slab and arch ring was so consolidated as to be practically as rigid as the slab itself the effect of this would be to concentrate nearly all the live and dead load carried by the slab on the crown of the arch, further increasing the bending moment at the crown; so that the method has its dangers. It would be better to fill up below the slab on each side with plain concrete as shown in Fig. 4, the centre B being filled with earth. This arrangement might be of use where the span of the arch was small and abutments very weak, as the slab would transfer the loading to the arch haunches and would at the same time act as a tie.

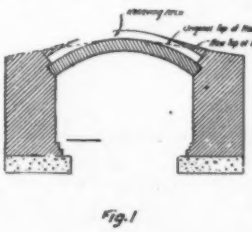


Fig. 1

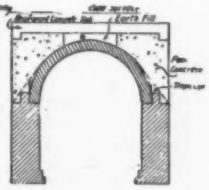


Fig. 4

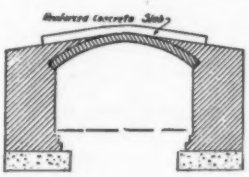


Fig. 2

Fig. 5

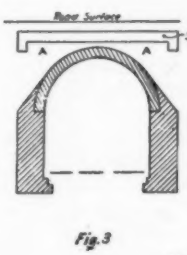


Fig. 3

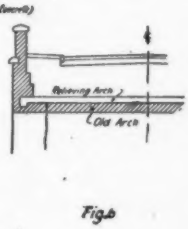


Fig. 6

Figs. 1 to 6

Strengthening Abutments.—Where the arch was a fair size and the abutments were insufficient to take the additional thrust of the relieving arch, it is better if possible to strengthen the abutments. Tie rods at the level of the springings are generally impracticable or unsightly. Sometimes where headroom and cross sectional area of opening are unimportant the relieving arch might be constructed within the existing one, the abutments being thickened inwards at the same time (Fig. 5). The objection here is that it is difficult to place the concrete of the relieving arch satisfactorily and also to ensure contact between relieving and existing arch when the centering was removed. Also, the old ring would carry the entire dead load except that of the new ring.

Handling Cracks in Arch Ring.—Sometimes cracks more or less parallel to the centre line of the roadway appeared in the arch ring due to spreading of the spandrel walls. The vault might then be tied together by transverse rods and plates, there being a rod above the extrados and one below the intrados to each pair of plates. A more satisfactory method where a relieving arch was employed and the spandrel walls were taken down and rebuilt would be to turn down the relieving arch (which must have good transverse reinforce-

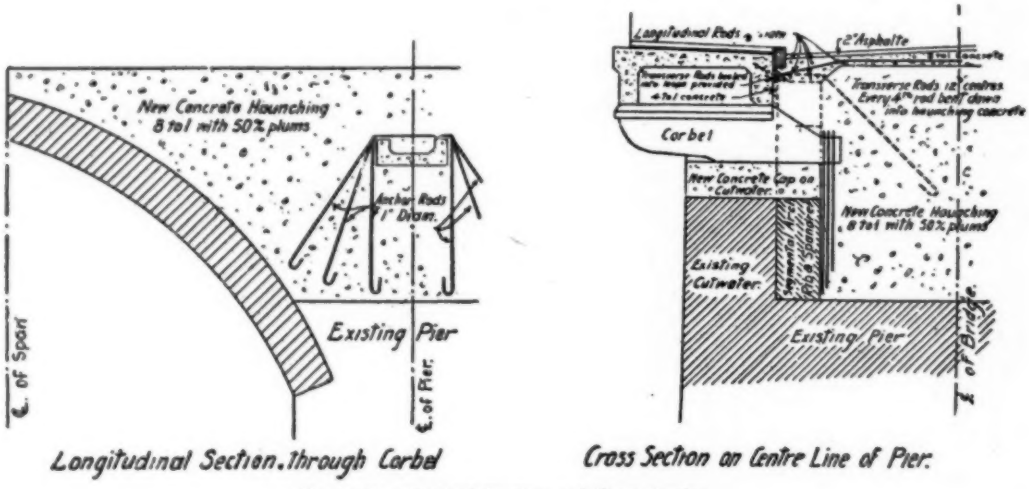
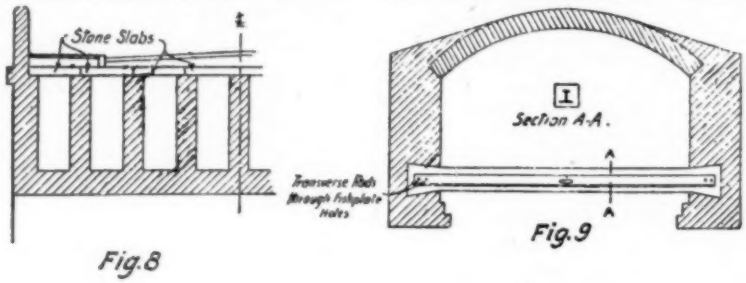
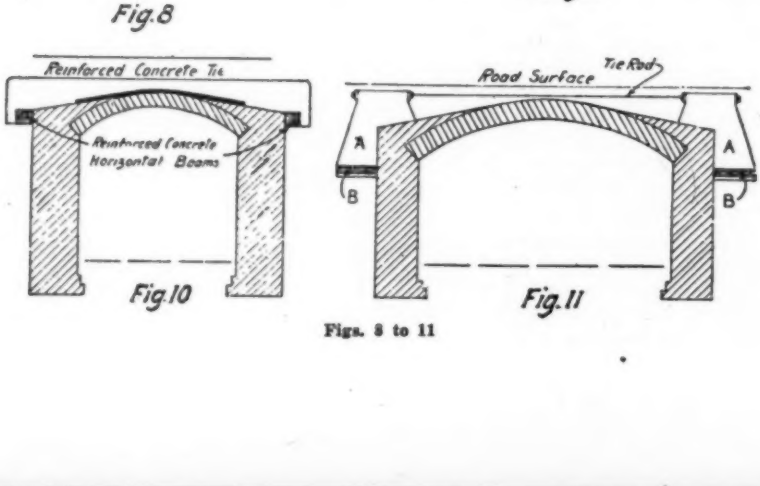


Fig. 7—Longitudinal Section and Cross Section.





Figs. 8 to 11

ment) well into the old arch ring (Fig. 6). Cracks in the old arch ring would, of course, be grouted up.

In the case of multiple-span bridges, particularly old bridges, the vault might be strengthened by backing it up deeply over the haunches, even up to the road formation (Fig. 7). The extra depth over the haunches, as in this case, might prove useful as a foundation or anchor for cantilevers carrying a footway or footways.

A few bridges have been constructed without filling, but with a series of parallel spandrel walls. These supported stone slabs, on which the roadway was carried (Fig. 8). Stresses in such a bridge were more or less indeterminate, and a relieving arch could not be employed for strengthening without removal of the internal spandrel walls. In most cases it was desirable to remove these internal walls, construct a relieving arch, strengthen the outer spandrel walls and fill the spandrels.

Strengthening Abutments.—If possible, abutments were best strengthened by excavating at the back in sections and thickening with mass concrete. Buttresses might be employed as an alternative. If spreading had occurred due to settlement of one or both abutments it was often possible to check this by the construction of ties formed of old steel rails securely anchored into the abutments below stream bed level. The ties could be surrounded with concrete (Fig. 9). It might occasionally be possible in the case of flat arches, where thickening of the abutments was difficult or costly, to strengthen the latter by the introduction of reinforced concrete ties above and distinct from the arch ring. Heavy point-loads should be prevented from coming on these ties. Such ties, which would be subjected to bending, should be constructed under the footways, and their ends would be united by reinforced concrete beams (Fig. 10). They should not be monolithic with the arch ring.

Where the roadway was of fair width ties beneath the footways might not be sufficient. A suggestion for such a case was shown in Fig. 11. Steel tie rods connecting reinforced concrete blocks AA could be employed, and might be conveniently spaced beneath the carriage-way. The blocks could be pre-cast, and pre-cast reinforced concrete slabs BB would be dropped in between them. The weight of the filling above these slabs would counteract the moment produced by the pull of the tie-rods. The filling behind the blocks and slabs should be well considered and the rods given some initial tension.

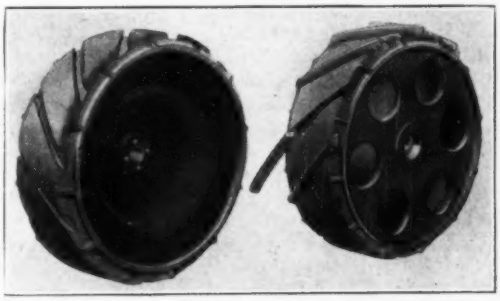
Another method was to anchor the blocks by steel rods into holes drilled vertically into the abutments; after the insertion of the rods the holes would be grouted up.

The strength of abutments was naturally influenced by the width of the bridge if the latter possessed substantial wing walls. In a narrow bridge a considerable proportion of the thrust was probably taken by the wing walls.

Many old bridges have been found when examined to be practically without abutments, yet had stood up to modern traffic. A new bridge of the same dimensions would fail, as the backing of its abutments would be unconsolidated whereas the backing of the old bridge would have been converted by years of traffic into a mass nearly as rigid as the abutments themselves.

Cast Wheels With Forged Lugs for Fordsons

The Wehr Co., Milwaukee, Wis., is now producing its own special cast wheel for Fordsons with quick detachable lugs. This new wheel is designed to fill an "in-between" need—to provide a wheel for travelling paved streets, and when lugs are attached to enable the Fordson to work in unusually loose ground. This



Cast Wheels With Forged Lugs for Fordsons

new Wehr cast wheel weighs 1,000 lb. It is cast hollow with openings on the inside of the wheel to permit loading with a mixture of cement and steel punchings, thus bringing the weight up an additional 400 to 700 lb. The lugs are drop forged from high grade steel, and are held in place by the tapered grooves cast in the rim of the wheel. One end of the lug has a "stop boss," the other end, a hole for a pin. The face of the wheel, with the lugs removed, is similar to that of a solid non-skid tire, with small lugs cast into the side of the wheel to assist traction when working in ruts, etc., with lugs removed. Shipping weight per set of two wheels, including 24 lugs, is approximately 2,200 lb.

The High Cost of Highway Bottlenecks

A Paper Presented April 30 at the Annual Meeting of the Highway Traffic Association

By G. E. HAMLIN

Superintendent of Repairs, Connecticut State Highway Department

The term "Highway Bottleneck" may be defined as a condition which retards the free movement of traffic, such condition being due to many varying causes. The popular idea of restriction of width while constituting one of the many bottlenecks, does not necessarily embrace the entire definition and in fact represents in all probability the smaller percentage of such condition.

If these retardation points are carefully analysed throughout any given length of heavy traffic highway the result will show causes of retardation, many of which can be eliminated with small expense compared with the value of the increased safe traffic flow.

Causes of Traffic Delays.—In this analysis observers must be capable of determining traffic values compared with elimination costs. Such a survey will develop among others these probable points of retardation:

Curves of small radius.
Restriction of width.
Entrance of connecting roads.
Obscured sight lines.
Improper cross section of travel path.
Warning signs of a design requiring time or effort to read.
Signs unnecessarily and frequently located tending to extreme caution or absolute disregard.
Slow moving vehicles in or near the road center.
Right angled intersections without provision for entrance to the main highway except by short turns, impractical for long wheel base vehicles or at excessive low speed.
The use of the highway unnecessarily by pedestrians.
Surface and seasonal condition of travel path including ruts, ice and snow.
Excessive parking of vehicles.
Draw bridges and grade crossings.
Accidents.

Need for Utilizing Present Highways to Full Capacity.—It may be taken for granted that the demand for road extension is in excess of the possible construction under available funds. Added to this is the necessary increase in maintenance costs of existing roadways due to age and increase in vehicle volume. The problem of satisfactorily furnishing transportation space on the highways for all vehicles desiring their use indicates the necessity of utilizing present systems to full capacity. Where conditions exist which limit such capacity below the potential maximum and unnecessary expense is paid by the motor vehicle user which while small, perhaps, to the individual is large in gross.

This expense in the case of the commercial motor vehicle is added to the commodity cost and is passed on to the ultimate consumer who, as usual, pays.

The tendency in general is to recommend the construction of additional or the widening of existing routes. In some cases this is the practical solution. But is such extension part of a permanent plan? Will this eventually form a necessary section of a through route? Is the territory served reasonably certain of continued increased growth of traffic or has it already reached its approximate maximum and the tendency developed for expansion of its business in other locations? Is this extension chargeable to bottlenecks in the existing highways? Is the service of other common carriers increasing to a point where competitive costs will eventually reduce the increasing demand for road truck service? This is in particular an economic question. When service is satisfactory from a viewpoint of economy, convenience, and time, such service will be utilized to its fullest extent. It may be well within the vision of a few years to have established large parking areas outside the congested central areas of the larger cities where connection by fast satisfactory service to the business center is furnished.

Seasonal condition of travel path may be one of the more important of the "bottleneck" conditions. We are expecting and demanding the free, convenient and unobstructed use of the highways each and every day of the year. The cost of non-use by reason of such seasonal condition extends beyond the mere transportation value to the factory, home and personal pocketbook.

I believe that such demand is justified, that the necessity for furnishing uninterrupted service must be realized and that such service must be reasonably safe and convenient.

Winter Road Conditions in A Central State.—This implies the keeping of the road surface

in good condition, the sanding of curves and grades when icy conditions prevail and in the northern states the removal of snow which impedes or delays free movement of traffic. In a recent issue of a Highway Commission Bulletin of a central state bordering a great river, this thought is brought to its citizens.

"This State has just passed through one of the longest and worst periods of bad roads which has been known since the motor vehicle became the chief means of transportation over the highways. The past six months would have been bad enough in the way of disturbance in business and social life, enforced isolation in the country districts and vexatious inconvenience generally for everybody in the horse stage of transportation, but in this motor vehicle age it has been, to say the least, discouraging and disheartening. People in the counties of the southeastern corner of the state have felt the situation more keenly perhaps than any other section. Because of unusual rain and snow and warmer winter weather with alternate freezing and thawing the roads throughout the entire territory have seldom been in usable condition and much of the time have been utterly impassable for motor vehicles. Perhaps the nearness of the paved road system of the neighbor state across the river has made the situation even more vexatious and trying for the people.

Our citizens have been rather boastful of the fact that they have been able to buy more automobiles per capita than the people of any other state. They have smiled rather superiorly at the jibes from other sections over the lack of roads on which to run these motor vehicles. Now, we of this rich old valley farm land, are beginning to suspect that perhaps these other peoples that have kept more even pace between their numbers of motor vehicles and their road improvement have really followed the more sensible course. Perhaps it might have been wiser to have noted and heeded earlier the lessons of their experience that the motor vehicle cannot supply satisfactory transportation unless it has a road bed on which to run."

Maintenance Requirements Differ.—No general standard can be set up for the proper maintenance of a travel path, this depending wholly upon the particular location and traffic necessity. The maintenance requirement for a main heavily travelled arterial highway differs greatly from that of the connecting secondary road and funds must be properly allotted with the relative values in mind.

In general, however, the principle holds that the secondary road must give continuous service, even if such service may not be of the same relatively high type of the arterial highway. The same slough hole may be pardoned the first year, may be excused the second, but should be cursed the third. If the curse extend beyond the road itself and fall upon the man in maintenance charge, the logical target is found.

This does not necessarily imply the possibility of available funds being sufficient to place long continuous sections of highway in perfect condition. It does, however, indicate the necessity of diverting a portion of the maintenance fund each year to the permanent repair of the worst spots in the highway so that such locations will not render the road impassable or restrict its use to loads of small volume with consequent high transportation cost.

The Effect of a Bottleneck.—The generally understood definition of the "bottleneck" consists of a restriction of width of right of way due to physical conditions at the location. This may be a narrowing of the available roadway or may be complicated by curvature with restriction of sight line which causes a retardation of the traffic flow. On a heavily travelled trunk line the effect of this retardation may be observed for some distance on either side. The removal of this obstruction or the relocation of the highway at this point may be indicated. This is in general the simplest form of the bottleneck and the one more easily solved.

An accident may cause delay to traffic and create a bottleneck condition to the greatest extent, particularly if it be of a serious nature. Car after car stops to investigate and remains while a personal examination is made. Each newcomer obtains the information obtained by those on the ground and transmits it to those who follow. Cars park on both sides of the highway leaving on the narrow road insufficient room for two vehicles to safely pass. A vehicle enters the lane from each end with a following line of cars. There can be no backing out without moving the entire line and generally someone insists that the other line should be the first to move. Each new vehicle adds to the difficulty and a traffic jam results. This is the situation which can be only handled by the state or traffic police. A highway patroled by a state police force, courteous and efficient, has proved to be the greatest factor in preventing traffic retardation, eliminating the dangerous driver, and affording a safe, convenient and reasonably fast passage over Connecticut highways.

What the Cook County Study Showed.—In the "Report of a Study of Highway Traffic & the Highway System of Cook County, Illinois" by the U. S. Bureau of Public Roads and the Cook County Highway Department, published in 1925, the following conclusions are drawn:

"Highway traffic in sections of the country particularly the zone surrounding the City of Chicago already exceeds the functional capacity of the improved routes in these sections;

and the great increase in traffic that may be expected during the next five years indicates that unless a comprehensive betterment program is initiated and substantially completed within this period, the county and the City of Chicago will suffer seriously from the lack of adequate highway facilities. The daily cost of highway congestion to the citizens of Cook County is excessive at the present time and will become enormous by 1930, unless additional highway improvements are made in the county and the city.

"The present system of improved highways is unsatisfactory for present traffic and an analysis of the reason for the inadequacy of the present system will be of value in developing the plan of highway improvement to fully serve present and expected future traffic."

In this Chicago traffic census at a grade railroad crossing on Western Avenue is shown a blocking of the crossing for an average of 17 minutes per hour with a maximum of 30 minutes in a single hour. At this point the traffic exceeds 15,000 vehicles per day.

The report also gives the conclusion as to cost of lost time due to similar traffic delays as follows:

"The utilization in 1924 of 418 miles of highway in the country was approximately 990,000 vehicle-miles per day. Assuming an average speed of twenty (20) miles per hour, the daily vehicle-hours are 49,500. Assuming that each vehicle loses four minutes per hour due to traffic congestion on the county highways caused by natural or artificial obstructions or indirect routes, there is a daily time loss to traffic of 3, 300 vehicle-hours. Considering the number of persons per passenger car and the net load per motor truck, the value of this lost time is at least $3.00 per hour. On this basis there is a daily net loss, due to traffic delays, of $9,900 on these 418 miles of highway. Assuming this condition to exist 300 days during the year, the annual loss is approximately $3,000,000."

Need for Immediate Relief.—The present cost of highway congestion indicates the necessity of a comprehensive plan for immediate relief and future extension commensurate with present and estimated future needs. This cost will increase rapidly, under an indefinite policy without accurate knowledge derived from an intensive study of actual and potential conditions.

The average present highway system is in general a growth of necessity, following rather than preceding actual traffic demands and based upon the easiest present solution rather than the future necessary solution. The connection of these separate units for increased traffic demands very frequently proves impractical and to the disadvantage of the larger unit where a direct continuous route of ample width is indicated.

The assumption of the excessive traffic cost of the "Bottleneck" and the realization of the necessity for reduction has resulted in many localities in the definite program for improvement which is now planned or in progress.

Traffic is becoming more critical and intolerant of unnecessary delay. This is a definite cost to the community which more often far exceeds the price of the remedy. The public in general has signified its desire for delay reduction and its willingness to accept the necessary financial obligation. To those in command the opportunity offered is unlimited.

Motor Vehicles in Great Britain

The total gross receipts shown in the British Ministry of Transport's motor taxation return for the period Dec. 1, 1925 to Feb. 28, 1926 amounts to £11,964,418, of which approximately £25,000 was refunded in respect of the surrender of 3,417 licenses. The total number of motor vehicles, including tramcars and trade licenses, in respect of which licenses were current on Feb. 28, 1926, may be taken as 1,177,000 including 498,000 cars taxed on horse power, 339,000 motor cycles; 232,000 commercial goods vehicles and 77,000 motor hackneys. As compared with the corresponding period, 1924-25, the total number of licenses current for this year shows an increase of 110,000. The increase in the number of cars taxed on horse power is 72,000, the number of motor cycle licenses has increased by 10,000, commercial goods vehicles by 25,000 and motor hackneys by only 1,000. The average receipt in respect of whole year licenses for cars taxed on horse power is £14/17/0 as against £15/8/0 on the previous return and, for commercial goods vehicles, £21/0/6 as compared with £21/1/6. Road locomotives have increased from 1,378 to 1,398. Horse-drawn vehicles, private and hackney, have decreased from 114,554 to 96,784.

Primary Road Maintenance In Iowa.—Primary road maintenance in Iowa, passed under control of the State Highway Commission on Nov. 30, 1925. During the weeks preceding this date arrangements were completed with practically every county in the state whereby the county engineer became maintenance superintendent for his own county. In two or three instances where the county did not, at the time, have a county engineer, arrangements were made for combining this county in a maintenance district with an adjoining county which had a county engineer. Arrangements were then perfected whereby the one county engineer became superintendent of the two counties.

Transportation Problems of Detroit

Unusual Conditions Described in Paper Presented Feb. 17 at 12th Annual Conference on Highway Engineering, University of Michigan

By COL. H. V. WALLACE

General Manager, Department of Street Railways, Detroit, Mich.

Detroit has much in common with other large cities in its transportation problems, but it also has many problems which are peculiar to itself and are perhaps unique in the urban traction field. As an instance, I might point out the intensive industrial life of the city not only lengthens our peak periods but increases the customary two periods to three district periods with some three or four semi-peak hours in the intervals.

The Position of the Street Railways.—But before I go into a classification of our problems, permit me first to present to you a word picture of the position of the Department of Street Railways in the transportation business. We are competing today with two common carriers—a privately owned motor bus company, which in several instances is operating parallel to our rail lines, and the irresponsible jitney; these jitneys also parallel our lines. Therefore, competition becomes one of our major problems.

An effort has already been made to clear the jitney from Detroit's streets and the case is now pending before the State Supreme Court. Section 23 of Amendment 14 to the City Charter confers power and authority in the Board of Street Railway Commissioners "to acquire, construct or purchase and to own, maintain and operate gasoline motor, trackless trolley busses, or such other types of trackless transportation as said Board may deem necessary or deirable for the purpose of supplying transportation to the inhabitants of the City of Detroit and within a distance of ten miles from any portion of its limits that the public convenience may require, together with all the necessary equipment therefor."

It will be seen from this that the railway lines of our city need suffer competition only until such time as they are financially able and disposed to eliminate it, and since the solution of this problem is obvious, I will make no further reference to it.

Location and General Contour of Detroit.—It might be well before I go on, for the benefit of those who are not familiar with the City of Detroit, to give a brief description of its location and general contour, for the geography of the city necessarily has considerable bearing on its transportation problems.

Detroit extends along the north bank of the Detroit River for a distance of approximately 12 miles and is solidly built up from the river in a generally northwesterly direction to a depth of about 9 miles. It is nearly rectangular in shape. The street system is somewhat complicated by three main diagonal arteries not including the main northerly artery, Woodward Ave., extending from the business center of the city. These three diagonal thoroughfares result in many intersections of the various car routes, which provide for quick facilities for transfers from the different quadrants of the city.

The business center is on the city's southerly edge approximately in the center of its river frontage, extending about ¾ mile along the river front and about the same distance inland.

One line of railroads enters the city in the southwesterly corner and extends diagonally across it from the business center. A second line of railroads extends from the westerly limits of the city, running southeasterly in a diagonal line to the business center. In addition to these, a belt line extends around the city approximately 6 miles from the center. Naturally the manufacturing district follows very closely along these railroads, which brings this district in an approximate semicircle 3 miles from the business section, while some of the larger plants lie in a circle from 5 to 6 miles from the center of the city.

It is interesting to note that our traffic surveys indicate that the majority of our people live on the side of the city opposite to which they work, that is, people engaged in plants on the westerly side of the city live on the easterly side, and vice versa, thus making it necessary for them to travel across the city to get to their work, while at the same time the people having either business or pleasure at the center of the city are swelling this same stream of traffic.

Detroit embraces an area of about 139 square miles. Therefore, the long haul problem in Detroit is a very real one. Perhaps an evidence of this can be given by the length of some of our car lines. We have a cross-town line running from the eastern to the western boundary of the city, a distance of 20 miles; another line, serving as a belt line and running around the city, on an average of

three miles from the center, is 15 miles in length. There are several lines in the nature of belt lines which approximate this same length of route. These belt lines intersecting as they do the various north and south routes, give, by transfer, very quick service to the center and manufacturing districts from the various parts of the city. Incidentally, I might point out that 30 per cent of our passengers use transfers.

Unusual Peak Period Conditions.—Now let me refer again to our unusual peak period condition. Many of the industrial plants work either two or three 8-hour shifts per day, employing thousands of men. There are probably very few railway systems in the world outside of Detroit that have a peak hour between 11 P. M. and 1 A. M. This peak is followed by the usual morning peak period from 6 to 9 to the business and industrial centers, and another in the afternoon from 3 to 6 o'clock. Since the starting time of these 8-hour shifts in our various industrial plants is not standardized, we find several periods which may well be termed semi-peaks.

This lack of standardization, however, is very desirable to the department since if the hours were standardized, we would require a tremendous increase in our rolling equipment to handle the armies of men who would pour into the streets. The department is very appreciative of the cooperation given by the industrial plants of the city in staggering their working hours.

Coordinated Coach Service.—While the transportation given by the department is fundamentally electric car service, a coordinated coach service used in conjunction with the car service is being rapidly developed. The rapid growth and expansion of the city has made it imperative that we go into the coach business to serve newly populated areas on the outer edges of the city where the density of population is sufficient to warrant organized transportation but does not warrant the heavy investment incident to the construction of rail lines.

The coach lines run generally as extensions to the car lines in territory not directly served by the street car. Others are laid out as belt lines through newly developed territory intersecting existing car lines, thus giving a similar service through the transfer to that maintained where the car lines exist. This coordinated service works out to the benefit of the city since the patrons originating their ride on a coach line can transfer, without additional cost, to a car line, and then upon payment of one cent, can obtain a transfer to other existing car lines in the city. There is no bigger bargain for sale in Detroit than its municipally owned transportation service.

The transportation industry today is in a state of flux. Many authorities maintain that the street car as such must give way to motorized transportation. Others declare that the motor coach can never replace the street car in handling mass transportation, that its function is that of a feeder or developer. Whether or not the motorization of our urban transportation systems will come about by the abandonment of car lines and the substitution of coach lines in the same streets; by the installation of coach lines on parallel streets, or some combination of the two, is an undecided question.

It is true, however, that the capacity of our city streets has been reached insofar as car tracks are concerned.

The great expansion of the city demands some form of rapid transit. This may be rendered in two ways; first, of course, by a system of subways or elevated lines, or by a coordinated express and local street car and coach service. We are studying the present time plans for such a coordinated service. These plans, which are still very much in the laboratory stage, would provide an express service by running street cars with stops approximately one mile apart. This service would be supplemented with a local coach service, or the reverse might be carried out with the coach in the capacity of an express.

One of the advantages of having the local service given by coaches is the ability of the coach to load and unload at the curb, thus avoiding a delay in the general flow of traffic, at the same time protecting passengers from the necessity of crossing through the traffic line to the center of the street to board the cars. The matter of protecting passengers either leaving or intending to board the cars is a very serious problem to us because of the many unusually wide thoroughfares in Detroit. We have several streets of 100 ft. width and our main east and west artery, Jefferson Avenue, is 120 ft. wide. It will be seen from this that the distance from the curb to the car tracks is equal to the width of the average street.

Since, from necessity, the street car stops should be at intersecting street car lines, which means that usually these stops would be where the main traffic on the highway would also stop, there would be an advantage in having the street cars make only such stops, and if a substantial saving in time is made by these express cars, it is not inconceivable that local passengers would transfer from local coaches to the express street car at these stops in order to get to the center of the city more rapidly.

Coordinated Coach and Express Car Service.—Such a coordinated local coach and express car service would naturally be given only in the more densely populated areas. In other

words, the coach routes would terminate approximately four miles from the center of the city, at which point the street cars would take up the local schedule to the end of the line. Studies of this coordinated service, which have been made by this department, indicate that on the longer lines reaching into the outlying sections, a saving of ten minutes can be made in the run from the center of the city to the terminus of the line.

Since the city is paying for the railway system and its operating costs from the fares received and from no other source, one of the questions which must be answered in whether a line of coaches as outlined above would serve as a feeder to the car lines or act as a competitor, thus cutting down income and defeating the plan of purchase and operation. The studies made so far, however, indicate that the business is sufficient to warrant both classes of service, particularly since the service would be so attractive that competing privately owned jitney and bus companies will be forced out of business. It appears that this may be the solution for the present problem of track saturation.

The Grade Crossing Problem.—In the first part of this paper I give a brief description of the location of steam road lines across the city in various directions. The problem of grade crossings in Detroit is a very acute one. As the steam roads serve the factories, there are many heavy freight trains passing over these various lines blocking our car lines and intersecting streets at intervals throughout the day and night. It has been estimated that the total cost of eliminating all Detroit grade crossings would amount to a figure somewhere between $40,000,000 and $50,000,000, and would require 20 years of constant effort in its accomplishment. The elimination of grade crossings on the Belt line alone, extended from Jefferson Avenue to the Dodge Brothers Motor Car Company, and of the Detroit Terminal within the city limits, would cost $17,000,000.

On the more important routes, the headways run from 1½ to 2½ minutes and the delays at railroad crossings result in a serious interruption to the car service and a tremendous annual expense to the Department of Street Railways. Some idea of our loss as the result of grade crossings can be had from the following figures:

During the month of November our lines lost 852 hours and ten minutes. During the month of December we lost 674 hours and 10 minutes and in the month of January our loss was 606 hours and 38 minutes, or a total for the three month period of 2,133 hours and 18 minutes. The dollars and cents cost of this loss of time is staggering—I will say nothing of the loss of good will of the citizens of Detroit which has a very high cash value.

Street Congestion.—Perhaps the most serious transportation problem is that resulting from street congestion. The Detroit Automobile Dealers Association has compiled figures showing that there is one car for each 3.5 persons in Wayne County and about 300,000 automobiles have been registered for the present year.

During the rush hours of the day within the business district congestion is so acute that our cars only maintain an average speed of approximately 4½ miles per hour. Naturally the speed of vehicles other than street cars which use the same thoroughfare can not maintain a much faster speed. Traffic surveys which have been made in the past disclose the fact that thousands of automobiles travel through this congested area in going from one side of the city to the other.

All officials of the city government having to do with traffic felt that much of this unnecessary travel through the congested area could be eliminated if a proper route in the form of a semi-circle could be provided just outside of the congested district. With this thought in mind a plan was developed to provide for such a route, and the Department of Public Works during the past year has widened the streets around this new traffic loop, and the Police Department has had installed traffic signals and have arranged to eliminate parking during the rush periods of the day. They have also designated certain one-way streets in this loop. Considerable advertising was given the plan through the press and it was put in effect on Feb. 8.

The timing of the signals was so arranged that drivers following the loop, averaging a speed of approximately 15 miles per hour, would have a clear signal ahead of them at each intersection.

The first week's operation of this plan despite the bad roadway conditions due to snow and ice indicates that it will materially relieve the congestion within the so-called half-mile circle. There are a few corrections which will have to be made in the timing of signals and the establishment of more one-way streets, but the plan in general is satisfactory.

Contrary to the general thought of five years ago, which was that the business district would move north from its present location, building activities in the present business area have been very great for the past two years and according to present indications, will continue for some time. Several large hotels and office buildings have been built within the mile circle and many more are contemplated. This, of course, aggravates the transportation problem greatly.

The majority of the car lines entering the downtown district are used to their capacity during the evening rush hours at present, and

with the continued building construction and the housing of thousands of additional employes in each of the buildings is causing us much concern.

A check taken of vehicles and passengers outbound from the business district between the hours of five and six P. M., disclosed 15,349 vehicles carrying 82,603 passengers. The street cars represented only 4.2 per cent of the vehicles and carried 58.23 per cent of the people. Busses were 1.2 per cent of the vehicles and carried 13.37 per cent of the people. Private automobiles constituted 79.3 per cent of the vehicles and carried only 25.64 per cent of the people. From this tabulation you may easily discern the uneconomical method of transportation, and which method constitutes the majority of the congestion—that is, the private automobile.

As we view it, the next step in the relief of congestion in the business districts of cities must come through the abolition of parking, the widening of streets, the establishment of additional one-way streets, and the giving of practically an absolute right-of-way over other vehicles to street cars and busses.

Ditcher Used for Covering New Concrete Pavement

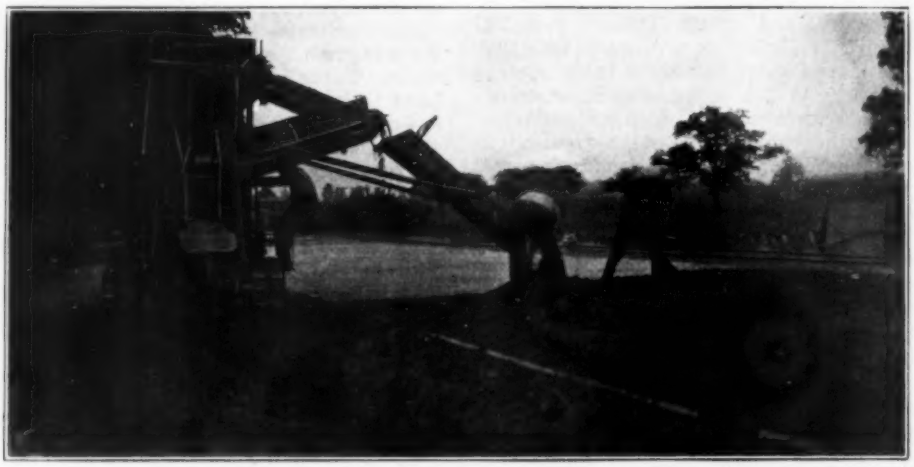
A regular Barber-Greene ditcher equipped with a conveyor and extension spout which deposits the dirt in the center of the pavement is used by G. P. Scharl, contractor, Grand Rapids, Mich., for covering new concrete pavement with earth. Two men are used generally for spreading the dirt uniformly over the surface. Before the machine was used there was usually a minimum of six men covering and where the ground was hard as many as 10 men were employed for this purpose. With this machince it is possible to cover this pavement at the rate of about 300 ft. per hour, thereby requiring only three or four hours to cover a day's run. The cost of sprinkling also is reduced as the machine covers much heavier than by hand, and thus holds the moisture much longer. Consequently it is not necessary to sprinkle so often.

The shallow ditch made by the machine is disposed of by running a small blade grader over it which fills the excavation nicely. Where the ground is exceedingly hard a plow is used, a furrow on either side being sufficient to fill the ditch.

"Treat 'Em Kindly" Stops Speeding

The "honor system" of enforcing highway traffic regulations in which arrests and courts are being displaced by kindness is being used by Pueblo county, Colorado. The system, which has been in operation for three months, has been highly effective, according to the board of county commissioners. There have been fewer serious accidents on the highways than when scores of speeders were haled into court and fined every month. The officials and general public are more pleased with the new system.

Speeders and other highway traffic violators are stopped by the county traffic officer, in much the same fashion that officers functioned under the "stop and arrest" system. The driver is advised that he or she has been exceeding the limit. A short explanation of the speed law and the necessity for it from the standpoint of protecting human lives is made. The officer then asks the driver and occupants to cooperate in making the highways safe. In nearly all cases the little talk makes a deep and lasting impression.



Ditcher Equipped With Conveyor and Extension Spout Covering Concrete Pavement